EMBODIMENT AND ITS EFFECTS: HOW CREATIVITY, PERCEPTION AND SENSORY PROCESSING SENSITIVITY LINK WITH EMPATHY AND THEORY OF MIND MECHANISMS

Jade Lorraine KIOU

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Abstract

Jade Lorraine Kiou

Embodiment and its Effects: How Creativity, Perception and Sensory Processing Sensitivity Link with Empathy and Theory of Mind Mechanisms

Keywords: Creativity, empathy, theory of mind, colour perception, sensory processing sensitivity

Embodied cognition is the study of how actions and interactions with objects and individuals affect cognitive processing. Neuroaesthetics deals with the neural, biological and evolutionary aspects of aesthetic experience which occur through the senses and consist of the emotional value placed onto objects, for example the appreciation of art work, dance, or music. These are individual and differ depending on level of expertise and experience within the art. The main aim of the thesis was to investigate the link between embodiment and aesthetics through examining people's level of creativity, colour perception and sensory processing sensitivity (SPS) in relation to levels of empathy and theory of mind (ToM). Research into this is sparse as the role of the body in relation to aesthetic experiences is a relatively new concept. Preference for portraits versus landscapes was also investigated to look at any role of social stimuli in aesthetic preference. Results demonstrate that participants with (i) higher levels of creativity (for some types of creativity) and (ii) more acute colour perception had higher levels of empathy/ToM. Individuals who had higher SPS demonstrated higher

empathy/ToM. It was also found that colour perception and empathy levels decrease with age, and aesthetic preference for portraits increase with age. These results have implications for education/schools, the prison service, for specific clinical conditions such as autism, Parkinson's disease, schizophrenia, and attention deficit/hyperactivity disorder, particularly given the role of dopamine in these disorders and in colour perception. Future research should investigate these findings using brain imaging and physiological measures.

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List of Definitions

Aesthetics

Relates to the senses, sensations and perception, and concerns the appreciation of beauty. Can be defined as the appreciation of beauty within nature. Relating to the arts and artworks, can be defined as the knowledge and appreciation resulting from an emotional response elicited by the perception of great works of art.

Aesthetics Sensitivity

Refers to an individual's level of awareness and appreciation of beauty.

Colour Perception

Occurs when light is transmitted through a substance and a small portion of the electromagnetic spectrum (wavelengths of ~400–700 nanometres) becomes visible to the human eye in the form of colour.

Cognitive Empathy

Refers to understanding the perspective of others.

Creativity

An act (the ability to produce something) or an idea/thought that is in some way novel (original, unusual, unexpected, unique) and appropriate (effective, useful, beneficial, fit for purpose, adaptive concerning task constraints).

Divergent Thinking (DT)

A component of the creative process, specifically creative thinking. DT task are an estimate (or a potential predictor) of creative problem solving. DT tasks are evaluated on fluency (the ability to produce a number of ideas for a certain problem), flexibility (the ability to see a problem from different approaches, scored by the number of different categories implied by the responses), and originality (the ability to produce unusual/unique responses).

Ease of Excitation

The extent to which an individual feels mentally overwhelmed by both internal (pain, hunger, taste) and external (light, noise) stimuli.

Embodied Cognition

A post-cognitivist approach that sees the body as the main actor in guiding cognition. Assumes that the body (including body morphology – the body's form and structure, sensory systems, motor systems, and emotions) have an influence on psychological processes.

Embodiment

When thoughts, feelings and behaviours are grounded in sensory experiences and bodily interactions with the environment, and how sensory, motor and perceptual processes influence thoughts, feelings and behaviours.

Emotional Empathy

Refers to sensing the feelings of others.

Empathic Concern

The level of sympathy and concern felt for other less fortunate than oneself. A type of emotional empathy.

Empathising

The ability to understand the thoughts and emotions of others, and in doing so, being able to respond to them in an appropriate manner.

Empathy

The capacity to understand and respond to the unique affective experiences of another person.

Fantasy

The extent to which an individual imagines themselves to be in the position of fictitious characters. A type of cognitive empathy.

Imagination

The mind's ability to conceive things which are not readily available to the senses.

Low Sensory Threshold

The extent to which an individual feels unpleasantly aroused by external stimuli such as bright lights and loud noises.

Mirror Neurons

Neurons in the brain that activate during the execution of an action, emotion or sensation, and the observation of the same action, emotion or sensation.

Neuroaesthetics

The neural, biological and evolutionary aspects of aesthetic experiences.

Personal Distress

The level of unease and anxiety felt during difficult situations. A type of emotional empathy.

Perspective Taking

The ability to understand another's point of view. A type of cognitive empathy.

Sensory Processing Sensitivity (SPS)

An innate trait which is characterised by greater sensitivity to social and environmental stimuli.

Systemising

The desire to analyse and build systems, with the intention of being able to understand and predict non-agentive events. Systems can be technical (e.g., the workings of a machine), natural (e.g., the process of coastal erosion), abstract (e.g., mathematics), motoric (e.g., a guitar playing technique), taxonomic (e.g., a criteria for ordering compact discs) or social (e.g., a taxation system).

Theory of Mind (ToM)

The ability to acknowledge mental states of the self and of others in order to predict behaviour based on those specific mental states, which may include beliefs, hopes, desires and intentions.

Chapter 1: General Introduction

1.1 Introduction

To successfully relate to and deal with other human beings, emotional and cognitive states must be understood. This ability, known as empathy, allows individuals to navigate in an otherwise unpredictable social world (Coutinho et al, 2014). Empathy concerns a large spectrum of phenomena, including the concern with other people and consequent motivation to help them, the capacity to resonate with the other's emotions, and the ability to understand a given situation from the perspective of another person in order to anticipate their actions, to name some examples (Coutinho et al, 2014). Humans can feel empathy for others in a number of different contexts, which includes basic emotions and sensations such as anger, fear, sadness, joy, pain, and lust, and also for complex emotions such as guilt, embarrassment, and love (Singer, 2006). Deficits in empathy have been associated with various clinical disorders such as psychopathology/antisocial personality disorders, borderline and narcissistic personality disorders, autistic spectrum disorders, alexithymia, and stroke/traumatic brain injury (Decety & Jackson, 2004; Decety & Moriguchi, 2007).

Empathic concern has been associated with prosocial behaviours such as helping a kin, and is considered a key process concerning altruism (Decety, 2006). While an impulse to care for offspring is almost certainly genetically hard-wired, it is less clear whether an impulse to care for siblings/more remote kin and non-kin, as well as other species, is genetically hard-wired (Decety, 2006). However, humans (unlike other species) are able

to put their emotions into words allowing them to state their emotions and to report on their current and past emotions. This enables the opportunity to share, explain and regulate emotional experiences with others, enabling empathy to develop. Such communication allows individuals to learn of their shared experiences and feelings with other individuals (Decety, 2006).

A relatively recent proposal made by Freedberg and Gallese (2007) assumes that empathy may be felt through the content and subject matter of art, and also, that empathy may be felt through the way in which the artist has creatively used their materials to convey a representation. According to Freedberg and Gallese (2007), embodied simulation may be a crucial factor in allowing the individual to empathize with others through activating their own internal representations concerning the actions, emotions, or sensations of the bodily states which are being expressed.

According to the embodiment theory, the body has an influence on psychological processes such as sensation, perception, attention, learning and memory (Glenberg, 2010). The body is seen as the main actor in guiding cognition (Ionescu & Vasc, 2014). Cognition is influenced and determined by bodily experiences in the physical world, thus important factors concerned with embodied cognition include representing the world, perceiving it and categorising it, and also acting and interacting with objects and individuals (Garbarini & Adenzato, 2004). The discovery of mirror neurons, which activate when the individual performs an action and when they observe or hear the same action (Di Pellegrino et al, 1992; Rizzolati et al, 1996), has provided evidence of embodiment, as it is proposed that individuals do not just perceive an action, emotion or sensation, but they

internalise the representations of the physical and neural states associated with it. Specifically, during social cognition, mirror neurons cause the visual information that an individual receives to be integrated into their own experiences so that they experience the observation as first person rather than third person (Ki, 2013).

Furthermore, the shared manifold hypothesis assumes that there is a link between mirror neurons and empathy (empathy is a main focus of the current research) (Gallese, 2001), and research has provided support for this (Gazzola et al, 2006; Kaplan & Iacoboni, 2006; Pfeifer et al, 2008). For example, in research conducted by Gazzola et al (2006), individuals who scored higher on an empathy scale showed stronger activation of the motor mirror system, and in a study conducted by Kaplan and Iacoboni (2006), participants watched both precision grips and whole-hand prehensions within the context of drinking and cleaning. Findings showed greater activity in the right inferior frontal mirror neuron area when precision grips within the drinking context were observed, and signal changes within the same area revealed a significant positive correlation on an empathy scale, showing increased signal changes for higher empathy scores (Kaplan & Iacoboni, 2006). In addition, activity was shown in the pars opercularis (the frontal component of the mirror neuron system) when participants observed and imitated emotional expressions in a study conducted by Pfeifer et al (2008). Therefore this shows that there is a link between mirror neurons and empathy. There are two main types of empathy, namely, emotional empathy and cognitive empathy (Shamay-Tsoory, 2011), and mirror neurons have

been shown to be involved in both (Gazzola et al, 2006; Kaplan & Iacoboni, 2006; Pfeifer et al, 2008; Shamay-Tsoory et al, 2009).

Along with various other neural systems, such as the reward network (Jacobsen et al, 2006; Kawabata & Zeki, 2004; Vartanian & Goel, 2004), the core emotion centres (the insula and the amygdala) (Cupchik et al, 2009; Di Dio et al, 2007), and the default mode network (Cela-Conde et al, 2013; Vessel et al, 2012; Vessel et al, 2013), the mirror neuron system has been shown to be involved in aesthetic experiences (Ticini et al, 2014). Furthermore, research into creativity and aesthetics has shown that experts process aesthetic experiences differently from laypeople (Bangert et al, 2006; Bhattacharyaa & Petscheb, 2002; Bhattacharya & Petsche, 2005; Calvo-Merino et al, 2005; Chamberlain et al, 2014; Kottlow et al, 2011; Leder et al, 2014), and research suggests that the mirror mechanism is strengthened through expertise and experience (Gallese, 2010). For example, stronger activations in various brain regions are shown in experts whilst observing others perform and also whilst performing themselves (Bangert et al, 2006; Calvo-Merino et al, 2005).

Through the course of this thesis, the overall intention is to generate further knowledge concerning the paradigm of embodied cognition by focusing on the way in which individuals interact with, and understand, the external world's stimuli and how this may affect, or be affected by, their level of sensitivity towards it. This will be done by investigating aspects such as (i) sensory processing sensitivity (SPS) due to its relation to embodiment, as it is characterised by greater sensitivity to social and environmental stimuli (Acevedo et al, 2014; Jagiellowicz et al, 2016), and (ii) colour perception

because of the association between colour and emotion (Clarke & Costall, 2008; Kaya & Epps, 2004; Terwogt & Hoeksma, 1995; Wexner, 1954) and the research showing that an individual's feelings and emotions may affect their perception of colour (Barrick et al, 2002; Fetterman et al, 2011; Sherman et al, 2012). Both SPS and colour perception are important factors to consider in the current thesis as it is questionable as to whether they are connected to empathy, and there is a gap in the literature concerning this. Other important factors that are focused on within this thesis are (iii) creativity and (iv) theory of mind (ToM) which is a form of cognitive empathy (Shamay-Tsoory, 2011).

In particular, the important questions that are raised in this thesis are: (i) does level of creativity affect empathy/ToM ability, (ii) can colour acuity predict level of empathy/ToM, (iii) does SPS affect empathy/ToM and does colour perception affect SPS. Currently, some of these questions have not yet been answered in a thorough manner, and some have never even been considered within previous research.

Firstly, although a link between creativity and empathy has been previously shown, only a few studies have investigated this (Carlozzi et al, 1995; Kalliopuska, 1989; Kalliopuska, 1991; Rabinowitch et al, 2013), most of which have focused on a child sample. The present research goes further by looking into different types of creativity in relation to different types of empathy within an adult sample, with the overall aim of deciphering whether those who are more creative are more empathetic. Secondly, the aim of addressing whether colour acuity can predict level of empathy and ToM ability, bridges a gap in the literature, as far as the researcher is aware, as

no previous research has looked into this, thus it is an important avenue of research which has various implications for future studies. For example, obtaining a greater understanding of the relationship between colour perception and social cognition may contribute to further understanding of the neural mechanisms involved in various social cognitive deficits such as those found in autism and other disorders such as attention deficit hyperactivity disorder (ADHD), schizophrenia, addictive behaviours and Parkinson's disease, particularly as they are all linked to a dysregulation of the dopamine system, and colour perception also involves the dopaminergic system. Thirdly, and to further investigate the role of embodiment, it is important to examine SPS in relation to empathy and ToM, and whether colour perception effects SPS, as much of the previous research has tended to focus on the negative aspects of SPS in general (Aron & Aron, 1997; Benham, 2006; Liss et al, 2005; Meyer & Carver, 2000; Neal et al, 2002), and by focusing on how SPS may be beneficial is needed in order to balance the literature. This will allow the field of neuropsychology to grow and would be beneficial to individuals high in SPS as it impacts on wellbeing and thus aids improved health.

1.2 Overview of Thesis Structure

This thesis is comprised of twelve chapters, three introductory and seven experimental. The following section gives a brief overview of each:

Chapter 2 discusses embodied cognition which is a topic in the cognitive sciences that sees the body as the main actor in guiding cognition (Ionescu & Vasc, 2014). This is important for the current thesis since it

focuses on aspects such as sensation (SPS) and perception (colour perception), as well as empathy/ToM, which are all concerned with embodiment. Mirror neurons, which provide support for embodied cognition (Gazzola & Keysers, 2009; Iacoboni et al, 1999; Kilner et al, 2009; Rizzolati et al, 1996), are discussed, as well as evidence for a link between mirror neurons and empathy. The types of empathy (including ToM) are also discussed, along with the theory of empathising-systemising, which posits that there are two opposing cognitive profiles, the male brain and the female brain. An overview of SPS which is an innate trait (Acevedo et al, 2014; Jagiellowicz et al, 2016) characterised by greater sensitivity to social and environmental stimuli is also given.

Chapter 3 discusses creativity, the ability to produce something, or to have a thought or idea, that is both novel (original, unusual, unexpected, unique) and appropriate (effective, useful, beneficial, fit for purpose, adaptive concerning task constraints) (Mumford & Gustafson, 1988; Runco & Jaeger, 2012; Sternberg, 1999), and aesthetics. Creativity is an important aspect to consider in the current thesis since creative individuals usually produce works that evoke feelings of empathy within its spectators (i.e. dancers, artists/painters, musicians). An aesthetic experience occurs through the senses and consists of the emotional value which is placed onto objects, allowing the beholder to perceive, feel, and sense (Brown & Dissanayake, 2009). This chapter focuses on how creativity is defined and measured, and an overview of aesthetics (the knowledge and appreciation of beauty and the emotional response elicited by the perception of great works of art) and Neuroaesthetics (research into the neural, biological and evolutionary

aspects of aesthetic experiences) is given. Previous research on aesthetic experiences is discussed, for example, various research shows a link between embodiment and aesthetics, showing a significant relationship between the participants' physiological responses during the perception of artwork and their self-reported aesthetic-emotional experience of the artwork (Tschacher et al, 2012). Furthermore, whilst viewing images of sculptures, the activation of the ventral premotor cortex and the posterior parietal cortex during the observation of the sculptures suggests motor resonance congruent with the movements portrayed in the sculptures (Di Dio et al, 2007). This chapter then focuses on the differences between experts when compared to laypeople.

Chapter 4 focuses on colour perception (a process that involves various areas in the brain) and its effects. Colour serves as an aesthetic and level of colour perception (colour acuity) is important to consider in the current thesis as it is an aspect of embodiment. Firstly, a description of how colour perception occurs is given. This is followed by a discussion of the research on how emotions can alter the perception of colour. Then the link between colour and emotion is discussed in terms of associations, and how colour can influence an individual's affect, cognition, and behaviour (Elliot & Maier, 2014). Since colour serves as an aesthetics it is often used by creative individuals to make spaces and objects appear more attractive (i.e. fashion design, interior design, advertisement, to name but a few), and its links with emotion and the influences it has on people. Thus, it is of interest whether/or how colour acuity relates to empathy.

Chapter 5 is the first experimental chapter. While the link between creativity and empathy has been examined (Carlozzi et al, 1995; Kalliopuska, 1989; Kalliopuska, 1991; Rabinowitch et al, 2013), an in-depth and thorough exploration of the link had not been provided until now. Specifically, this chapter investigates how level of creativity (for different types of creativity - specifically, self-reported creative achievement, creative behaviours and a test of creative cognition) has an effect on level of empathy (for different types of empathy - including self-reported emotional empathy and emotional & cognitive empathy taken as a whole). Measures that were used are: the Creative Achievement Questionnaire (CAQ; Carson et al, 2005; Appendix 4), the Biographical Inventory of Creative Behaviours (BICB; Batey, 2007; Appendix 1), the Alternate Uses Test, Form B Test Booklet (AUT; Guilford et al, 1960; Appendix 6), the Interpersonal Reactivity Index (IRI; Davis, 1983; Appendix 5), and the Toronto Empathy Questionnaire (TEQ; Spreng et al, 2009; Appendix 9). The findings revealed no significant difference in empathy based on creative achievement. However, important and significant differences were found in various types of empathy based on creative behaviours and creative cognition (divergent thinking) in that as creativity score (behavioural and cognitive) increased so did levels of empathy, with a clear and strong relationship. This suggests that there is a complex link between creativity and empathy, whilst also providing some support for previous research and the current hypothesis. These findings could be considered as a marker for guiding future neuroscientific experiments into the brain regions and neural mechanisms/processes involved in the specific types of creativity and empathy, as so far this remains ambiguous.

Chapter 6 is the second experimental chapter. Following the findings of the experiment of Chapter 5, it was important to look into the effects of creativity on ToM ability, as ToM is a form of cognitive empathy (Shamay-Tsoory, 2011). Such research is important for autism (as those with autism have impaired ToM) and the wider field of social cognition. Therefore this chapter's experiment focuses on the link between creativity and ToM. Again it looks into the different types of creativity in relation to ToM through two separate measures varying in difficulty, specifically, the Reading the Mind in the Eyes Test, Revised Version (Baron-Cohen et al, 2001; Appendix 7) and the Faces Test (Baron-Cohen et al, 1997; Appendix 8). The ToM Eyes test (which merely shows an image of the eye region) is more difficult than the ToM Faces test (which shows an image of the full face). Little research has investigated creativity and ToM, with only a few studies examining any link between the two (Suddendorf & Fletcher-Flinn, 1997; Suddendorf & Fletcher-Flinn, 1999), however, both of these studies have utilised child samples. Similar to the previous chapter, findings showed no effect of creative achievement on ToM. However, significant effects were found in ToM based on creative behaviours and divergent thinking, which showed a clear relationship, thus providing some support for the current hypothesis and the previous research. This is particularly important since social cognitive skills such as ToM and empathy guide everyday interactions and are imperative when it comes to co-operation and sociocultural learning, and deficits in such skills have been associated with pathologies such as sociopathy, autistic spectrum disorders, and nonverbal learning disorders (Goldstein & Winner, 2012). This leads on to the next chapter which focuses on colour perception

and empathy, as colour serves as an aesthetic and is involved in many aspects of creativity, and colour perception is also an aspect of embodiment.

Chapter 7 is the third experimental chapter. This chapter investigated colour perception as a predictor of empathy. Much research has examined the relationship between colour and emotion (Clarke & Costall, 2008; Dijkstra et al, 2008; Elliot & Niesta, 2008; Kaya & Epps, 2004; Kuller et al, 2009; Terwogt & Hoeksma, 1995; Wexner, 1954; Yildirim et al, 2007), however, this is the first, as far as the researcher is aware, to examine colour perception as a predictor of empathy in particular. Colour acuity was measured via the Farnsworth-Munsell 100 Hue Colour Vision Test (Farnsworth, 1957; Appendix 3) and empathy was measured via self-report as before, specifically using the IRI and TEQ. Findings revealed colour acuity to be a significant predictor of empathy for both emotional empathy and for emotional and cognitive empathy taken as a whole. This is an exciting finding. Exploratory analysis into the subscales of the IRI revealed level of colour acuity to have a significant effect on perspective taking and fantasy (both cognitive empathy subscales), but no significant effect on empathic concern or personal distress (both emotional empathy subscales). Finding are discussed in relation to dopamine which has been shown by previous research to be linked to both colour perception and cognitive empathy. This is followed by the next chapter which focuses on colour perception and ToM, the next logical exploration in this thesis.

Chapter 8 is the fourth experimental chapter. Research currently fails to extend the concept of the link between colour and emotion to an understanding of whether there is a relationship between an individual's level

of colour perception and their ability to accurately perceive emotions. Colour perception as a predictor of ToM is investigated within this chapter, extending that of the previous chapter as ToM is a form of cognitive empathy. This is again the first experiment, as far as the researcher is aware, to examine colour perception as a predictor of ToM. The same measures of colour perception and ToM were employed as in the previous experiments within this thesis. Colour acuity was found to be a significant predictor of ToM for the Eyes Test, but not for the Faces Test. These findings provide some support for the previous research on colour and emotion, as well as autism research, and are discussed in relation to dopamine. The next chapter goes on to investigate SPS in relation to empathy, ToM and colour perception.

Chapter 9 is the fifth experimental chapter. This chapter focuses on SPS, empathy, ToM and colour perception in order to discover whether they are linked, as SPS is a trait that is embodied, and the measure of SPS used in this experiment has a subscale that measures aesthetic sensitivity (HSPS; Aron & Aron, 1997; Appendix 10). Firstly, the experiment investigates whether there is an effect of SPS on empathy and ToM, and secondly, the experiment investigates the effect of colour perception on SPS. It was shown that SPS has a significant effect on level of empathy and ToM; specifically that highly sensitive individuals have higher empathy levels/ToM ability. This was shown for emotional & cognitive empathy taken as a whole, emotional empathy, and ToM. This experiment also revealed a significant effect of colour acuity on SPS. Such findings have implications for clinical disorders such as autism, and may explain why autism is linked to sensory

processing disorder (Kern et al, 2006). Following this, the thesis goes on to look into the effects of age on aspects such as colour perception, empathy, and preference for paintings. This is particularly important since people's thoughts and faculties tend to change/deteriorate with age, thus it was important to look at how colour perception and empathy may alter.

Chapter 10 is the sixth experimental chapter. This chapter focuses on the effects of age as previous research suggests that colour perception deteriorates with age (Kinnear & Sahraie, 2002; Roy et al, 1991; Verriest et al, 1982), as does empathy/emotional recognition in cohort designs (Grühn et al, 2008; Phillips et al, 2002; Ruffman et al, 2008; Schieman & Van Gundy, 2000), thus it is an important aspect to consider in the current thesis. This is examined in relation to colour perception and empathy. Furthermore, it is hypothesised that people with higher levels of empathy/ToM may have a higher preference for portrait paintings compared to landscapes (Appendix 12) (this is investigated in the current thesis since portraits relate to the empathy/ToM aspect that is focused on throughout the thesis). This is especially important since Freedberg and Gallese (2007) assume that empathy may be felt through the content and subject matter of art (i.e. portraits/faces compared to landscapes). The findings of this chapter revealed that, consistent with previous literature, colour perception deteriorates with age, levels of empathy (for all types of empathy, including both emotional empathy and cognitive empathy) decrease with age, and interestingly preference for portraits increases with age, thus providing support for the hypotheses and previous research. This suggest that age has an effect on both aesthetics and social/emotional cognition. The finding

concerning portraits suggests that as age increases, preference for portraits over landscapes also increases, indicating that older adults find portraits more pleasing.

Chapter 11 is the seventh experimental chapter. This last experimental chapter looks into a creativity questionnaire which examines each creative behaviour individually in relation to each dependent variable studied within the thesis, as it was important not to miss any potentially important findings in regard to creativity, and given that there was quite a consistent finding of non-significance using this creativity questionnaire, this methodology was investigated in itself to explore why no effects were being seen. This chapter examines the creative achievement questionnaire (CAQ: Appendix 4) (which includes different creative behaviours) in relation to all of the dependent variables within the thesis, in order not to miss any potentially important findings. High and low scores in each creative behaviour were compared. It was found that those who scored low in music had a higher level of divergent thinking ability, contrary to previous research. Those scoring high in humour also had better divergent thinking ability. It was also found that individuals scoring low in architectural design had higher levels of emotional empathy, and those who scored high in inventions had better imagination. As there is little or no previous research regarding some of these findings, it is important for future research to examine these thoroughly in samples of experts compared to laypeople. The results of this chapter imply that a potential of using this questionnaire is that it appears to be perhaps better suited at measuring Big-C creativity (eminent or genius level creativity) rather than little-c creativity (everyday creativity), and it is

important to look at the individual creative behaviours that are stated within the questionnaire, as well as the overall combined creativity score. The next chapter will focus on a discussion of the research within the thesis.

Chapter 12 is the discussion chapter which summarises the main findings of the thesis. It also suggests some possible ideas for future work, and discusses the implications of the thesis. A conclusion is then provided.

1.3 Chapter Highlights

- Empathy involves being concerned with other people and a consequent motivation to help them, the capacity to resonate with the other's emotions, and the ability to understand a given situation from the perspective of another person in order to anticipate their actions.
- Humans can feel empathy for others in a number of different contexts, including for basic emotions and sensations, and also for complex emotions.
- Deficits in empathy have been associated with various clinical disorders.
- Freedberg and Gallese (2007) assume that empathy may be felt through the content and subject matter of art, and also, that empathy may be felt through the way in which the artist has creatively used their materials to convey a representation.
- Embodied simulation may be a crucial factor in allowing the individual to empathize with others through activating their own internal representations concerning the actions, emotions, or sensations of the bodily states which are being expressed.

- According to the embodiment theory, the body has an influence on psychological processes such as sensation, perception, attention, learning and memory, and is seen as the main actor in guiding cognition.
- The discovery of mirror neurons, which activate when the individual performs an action and when they observe or hear the same action, has provided evidence of embodiment.
- The shared manifold hypothesis assumes that there is a link between mirror neurons and empathy.
- The mirror neuron system has been shown to be involved in aesthetic experiences.
- Experts process aesthetic experiences differently from laypeople and the mirror mechanism is strengthened through expertise and experience.
- This thesis is comprised of twelve chapters, three introductory and seven experimental.
- Chapter 2 focuses on mirror neurons, empathy, and sensory processing, which are all concerned with embodiment/embodied cognition.
- Chapter 3 discusses creativity and aesthetics.
- Chapter 4 focuses on colour perception and its effects.
- Chapter 5 is the first experimental chapter, which focuses on creativity and empathy, and has shown a link between the two.
- Chapter 6 investigates creativity and ToM, a form of cognitive empathy, and also found a link between the two.

- Chapter 7 investigates colour perception as a predictor of empathy, and found colour acuity to be a significant predictor of empathy.
- Chapter 8 examines colour perception as a predictor of ToM, and colour acuity was found to be a significant predictor of ToM for the Eyes Test.
- Chapter 9 focuses on SPS, empathy, ToM and colour perception, and it was shown that highly sensitive individuals have higher empathy levels/ToM ability, and also revealed a significant effect of colour acuity on SPS.
- Chapter 10 investigates the effects of age, showing that colour perception deteriorates with age, levels of empathy decrease with age, and preference for portraits increases with age.
- Chapter 11 examines the CAQ in relation to all dependent variables in the thesis, and significant findings were found for music, humour, architectural design, and inventions.
- Chapter 12 is the discussion chapter.

Chapter 2: Embodied Cognition: Mirror Neurons, Empathy and Sensory Processing

2.1 Embodiment, Mirror Neurons and Empathy

Cognition is no longer considered to be different from perceiving and acting, as the post-cognitivist approach, labelled embodied cognition, sees the body as the main actor in guiding cognition (Ionescu & Vasc, 2014). Acting and interacting with objects and individuals, as well as representing the world, perceiving it and categorising it, are important factors concerning embodied cognition (Garbarini & Adenzato, 2004). Thus, according to the embodiment theory, the body (including body morphology – the body's form and structure, sensory systems, motor systems, and emotions) have an influence on psychological processes (Glenberg, 2010).

The discovery of mirror neurons in macaques (Di Pellegrino et al, 1992), which later led to the finding of a mirror mechanism within the human brain (Gazzola & Keysers, 2009; Iacoboni et al, 1999; Kilner et al, 2009; Rizzolati et al, 1996), has provided evidence in support of embodied cognition. The discovery of mirror neurons first transpired from a series of experiments conducted on a macaque monkey (Di Pellegrino et al, 1992). The experiments initially aimed to investigate neuronal activity within the pre-motor cortex, specifically area F5, in order to establish the difference between stimulus associated responses and activity based movements (Di Pellegrino et al, 1992). However it was found that neurons within this area not only discharged when the monkey performed goal-directed movements,

but also when it observed the same actions conducted by the experimenters (Di Pellegrino et al, 1992). In a paper four years subsequent to this finding, these particular neurons were labelled as mirror neurons (Gallese et al, 1996). The mirror neuron system in the human brain consists of the pars opercularis and adjacent ventral premotor cortex, and the anterior inferior parietal lobule (Pfeifer et al, 2008). It has been suggested that mirror neurons are an integral component in explaining a large degree of social cognitions (Hayes, 2010), including imitation (Miall, 2003; Rizzolati et al, 2001), empathy (Gallese, 2001), mind reading (Gallese & Goldman, 1998), and linguistic communication (Gallese, 2008).

A direct link between mirror neurons and empathy was proposed by Gallese (2001) in the shared manifold hypothesis. The word 'empathy' originates from the Greek word 'empatheia' which translates to 'passionate' and is composed of 'em' (in) and 'pathos' (passion, suffering, experience, feeling, emotion); scientifically deriving from its use in philosophical aesthetics, where the English term later transpired directly from the German word 'einfühlung' (Singer & Lamm, 2009). The importance of empathy in relation to aesthetics was articulated by Robert Vischer in 1873, where he referred to the term as the physical responses that occur during the observation of paintings (Freedberg & Gallese, 2007). Thus, although originally deemed as a tool by which works of art and nature could be analysed, the term later became known as 'the capacity to understand and respond to the unique affective experiences of another person' (Decety & Jackson, 2006: 54). Gallese (2001) posits that it is through a shared manifold that individuals are able to recognise other human beings, and that

it is a mirror matching mechanism which allows others' pains, emotions and sensations to be empathised with and understood. Various brain imaging studies have provided support for this, specifically showing overlapping brain activations in individuals who are feeling their own emotions and observing the same emotions in others (Jabbi et al, 2007; Morrison et al, 2004; Ochsner et al, 2008; Singer et al, 2004; Wicker et al, 2003). Therefore, the implication is that embodied simulation plays a role in the way in which individuals empathise with others, as the individual's own internal representations of others' bodily states are activated via the perception of actions, emotions, or sensations which are associated to various social stimuli (Gallese, 2005). Hence, the activation of the same brain region during the execution of an action, emotion or sensation, and the observation of the same action, emotion or sensation, allows the individual to understand and empathise with others.

2.2 Types of Empathy

Rather than being viewed as a unitary concept, empathy may be seen as comprising of several components (Mazza et al, 2014). Particularly, empathy may be viewed as being an emotional construct which involves sensing the feelings of others, however it could also be viewed as being a cognitive construct which would involve understanding the perspective of others (Shamay-Tsoory, 2011). Based on neuroscientific findings, it has been suggested that both emotional empathy and cognitive empathy may comprise of two separate neural systems, thus being distinct (Shamay-Tsoory et al, 2009; Shamay-Tsoory, 2011). Nevertheless, these systems may overlap to a certain extent, as any response based on feelings of

empathy may evoke both components, depending on the social context of the event. Moreover, an fMRI based quantitative meta-analysis has identified that specific brain regions are consistently activated during empathy in general; these include the dorsal anterior cingulate cortex, anterior medial cingulate cortex, supplementary motor area (dACC-aMCC-SMA) and the bilateral anterior insula (Fan et al, 2011).

The two main elements of empathy (emotional empathy and cognitive empathy) can each be further split into several components of their own. For instance, aspects such as emotional contagion, emotion recognition, shared pain, empathetic concern and personal distress, are regarded as being forms of emotional empathy (Davis, 1980, 1983; Shamay-Tsoory, 2011). Whereas, affective mentalizing, cognitive mentalizing, perspective taking and fantasy, are viewed as forms of cognitive empathy (Davis, 1980, 1983; Shamay-Tsoory, 2011). The term mentalizing is also referred to as theory of mind (ToM). According to Decety and Moriguchi (2007), there are four key components which interact in order to create an experience of empathy: (i) affective sharing which occurs between the self and the other through automatic mirroring, (ii) self-awareness which refers to the distinction between self and other, (iii) mental flexibility which allows the others' perspective to be adopted, and (iv) regulatory processes which control the subjective experiences concerning the emotion. Thus, it is evident that empathy is a complex phenomenon concerning numerous components and several brain networks.

Research pertaining to the current thesis has specifically employed measures of emotional empathy, ToM as a form of cognitive empathy, and

emotional and cognitive empathy as a whole. These include, the Toronto Empathy Questionnaire (TEQ; Spreng et al, 2009; Appendix 9) which was developed to measure empathy primarily as an emotional process and the Interpersonal Reactivity Index (IRI; Davis, 1980, 1983; Appendix 5) which is a questionnaire that measures both emotional and cognitive empathy and contains four subscales: (i) perspective taking (the ability to understand another's point of view – cognitive empathy), (ii) fantasy (the extent to which an individual imagines themselves to be in the position of fictitious characters – cognitive empathy), (iii) empathic concern (the level of sympathy and concern felt for other less fortunate than oneself – emotional empathy), and (iv) personal distress (the level of unease and anxiety felt during difficult situations - emotional empathy). ToM was measured through the Faces Test (Baron-Cohen et al, 1997; Appendix 8) and the Reading the Mind in the Eyes Test, revised version (Eyes Test; Baron-Cohen et al, 2001; Appendix 7). The Faces Test depicts images of the full face expressing both basic and complex mental states, each of which contain a choice of two words describing an emotion, one being the word which correctly describes the emotion expressed in the image and the other being incorrect. The Eyes Test is similar with increased difficulty, containing images of the eye region only, with a choice of four words, one of them is the correct emotion being expressed, and the remaining four are incorrect.

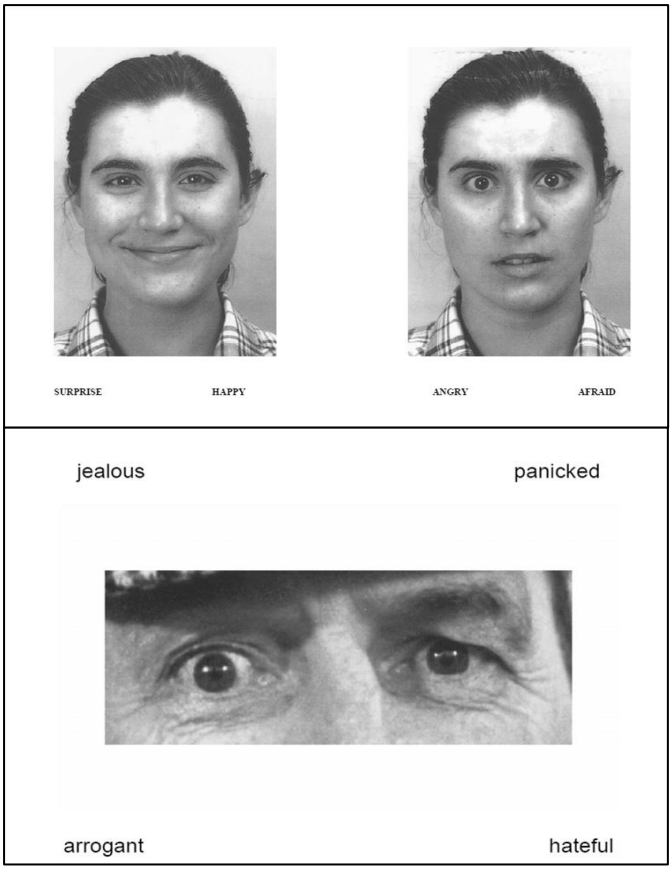


Figure 1: Example of ToM faces and ToM eyes

ToM can be defined as the ability to acknowledge mental states of the self and of others in order to predict behaviour based on those specific mental states, which may include beliefs, hopes, desires and intentions (Premack & Woodruff, 1978). Differing views concerning ToM have been put forward, namely theory-theory and simulation theory (Gallese & Goldman, 1998). The theory-theory account of ToM asserts that individuals acquire a common sense ToM whereby they attain the mental states of others via theoretical reasoning, which involves tacitly known causal laws (Gallese & Goldman, 1998). This therefore suggests that ToM is developed through learning and experience, whereas, the simulation theory considers ToM to be

innate and intuitive (Völlm et al, 2006). The simulation theory, which posits that an individual uses their own mental mechanisms to imagine and envisage the mental states of others, fits well with findings on mirror neuron activity (Gallese & Goldman, 1998).

2.3 Mirror Neurons and Types of Empathy

It is evident that the mirror neuron system is involved in the experience of empathy. Research shows that physically experiencing a sensation activates the same brain regions as watching another person experience that same sensation (Jabbi et al, 2008; Singer et al, 2004; Wicker et al, 2003). This has been shown for the sensation of pain in an experiment conducted by Singer et al (2004). The experiment consisted of 16 couples that were subjected to a painful stimulation via an electrode attached to the back of the right hand. It was indicated to each couple whether they or their partner would feel pain or not. Findings revealed brain activation in the bilateral anterior insula, rostral anterior cingulate cortex, brainstem, and the cerebellum during the painful stimulation and also when signalled that their partner was experiencing the painful stimulation. Moreover, stronger brain activations were apparent for individuals who scored higher on general empathy scales whilst perceiving their partner experiencing the painful stimulation (Singer et al, 2004). Similarly, research has shown that physically experiencing disgust, through inhaling odorants which produced a feeling of disgust, activated the same brain region as watching video clips of others showing the same emotion through facial expression (Wicker et al, 2003). Jabbi et al (2008) also provide similar findings showing that

observing, imagining, and experiencing the emotion of disgust, elicit the same brain regions.

Furthermore, various research has shown that both emotional empathy and cognitive empathy may involve mirror neurons. In particular, several research findings show links between mirror neuron activity and emotional empathy (Kaplan & Iacoboni, 2006; Pfeifer et al, 2008; Shamay-Tsoory et al, 2009). For example, in a study by Kaplan and Iacoboni (2006), participants watched both precision grips and whole-hand prehensions within the context of drinking and cleaning. The findings showed greater activity in the right inferior frontal mirror neuron area when precision grips within the drinking context were observed, and signal changes within the same area revealed a significant correlation on the Empathic Concern subscale of the Interpersonal Reactivity Index (Davis, 1980; Appendix 5). This suggests that mirror neuron areas within the human brain use grasping information, as well as contextual information, in order to predict others' intentions. This therefore implies that mirror neuron activity is an important factor in social competence, specifically the ability to understand the intentions of other people through cognitive empathy (Kaplan & Iacoboni, 2006). Furthermore, empathy and interpersonal competence were examined within a sample of 16 children at the age of 10 years (Pfeifer et al, 2008). Activity was shown in the pars opercularis (the frontal component of the mirror neuron system) when participants observed and imitated emotional expressions. The activity in this particular area, and in the anterior insula and amygdala (areas related to emotion), showed a positive and significant correlation on behavioural measures of empathy (Pfeifer et al, 2008). In addition, Shamay-Tsoory et al

(2009) examined participants with lesions to the ventromedial prefrontal or inferior frontal gyrus cortices, as well as two control groups. Participants were assessed on empathy measures involving both emotional and cognitive dimensions. An area of the mirror neuron system, Brodmann area 44 (also known as the pars opercularis), was found to be vital for emotional empathy, but not cognitive empathy (Shamay-Tsoory et al, 2009). Broca's area in humans, the first area to be identified as involved in language, consists of Brodmann area 44 and 45, therefore there is an overlap between action imitation and language, which suggests that mirror neurons were involved in the evolution of language (Corballis, 2010), and not only imitation and emotion recognition (Shamay-Tsoory et al, 2009).

However, other research has shown a correlation between mirror neuron activity and cognitive empathy, whilst also providing evidence of a human auditory mirror system within a sample of 16 participants (Gazzola et al, 2006). The research shows that the left hemispheric temporo-parieto-premotor circuit is activated during the observation of motor execution, and also whilst listening to the sound of an action conducted by the same person, therefore suggesting that this is a multimodal system. The study also suggests that there may be a link between cognitive empathy and the motor mirror system, as individuals who scored higher on an empathy scale, specifically perspective taking, showed stronger activation of the motor mirror system (Gazzola et al, 2006). The research thus shows a link between empathy and embodiment through mirror neurons.

2.4 Empathising-Systemising

Baron-Cohen (2002) proposed a two dimensional theory based on sex differences in cognition. The two dimensions include empathising and systemising. The theory suggests that there are two opposing cognitive profiles, the male brain and the female brain, whereby an individual is significantly better at either empathising than systemising, or vice versa. Empathising refers to the ability to understand the thoughts and emotions of others, and in doing so, being able to respond to them in an appropriate manner (Baron-Cohen, 2002). Systemising, on the other hand, can be defined as the desire to analyse and build systems, with the intention of being able to understand and predict non-agentive events. 'Systems can be technical (e.g., the workings of a machine), natural (e.g., the process of coastal erosion), abstract (e.g., mathematics), motoric (e.g., a guitar playing technique), taxonomic (e.g., a criteria for ordering compact discs) or social (e.g., a taxation system)' (Lawson et al, 2004: 302).

The empathising-systemising (E-S) theory was devised in relation to autism spectrum disorder which was observed to present the extremes of characteristically male behaviours, particularly as the typical autistic profile includes a hyper-developed systemising ability and a hypo-developed empathising ability; which has been labelled as the extreme male brain (Baron-Cohen, 2002). Although the E-S theory was devised in relation to autism, a study was conducted in order to examine E-S in a sample of adults both with and without Asperger Syndrome (AS) (Lawson et al, 2004). A bias towards either empathising or systemising was found in the AS group and also in the general population. However, no significant correlation was found

between the Social Stories Questionnaire (SSQ – a measure of empathising) and the Physical Prediction Questionnaire (PPQ – a measure of systemising), either overall or within any of the groups. Therefore it seems that an individual's ability to empathise and their ability to systemise are independent of each other (Lawson et al, 2004). Similarly, the findings of various other studies concur with this by showing no significant relationship between measures of E-S (Carroll & Yung, 2006; Ling et al, 2009; Russell-Smith et al, 2013). However, contrary to this, there are studies which have found a negative correlation between the two (Baron-Cohen et al, 2003; Baron-Cohen & Wheelwright, 2004; Jarrold et al, 2000). This could suggest one of two issues: (i) either there are flaws within the data, or (ii) if a relationship does indeed exist, it may be more complex than initially thought and thus involve a number of other factors. Thus, it is ambiguous as to whether empathising and systemising are completely independent, or whether they are separate yet related constructs.

Sex differences in the general population are apparent in E-S, with females tending to score higher on measures of empathising and males scoring higher on measures of systemising (Baron-Cohen & Wheelwright, 2004; Chou et al, 2011; Cook & Saucier, 2010; Manson & Winterbottom, 2012). Furthermore, empathising and systemising have been investigated in relation to a number of other factors such as anxiety levels (Strutt et al, 2014), jumping to conclusions (Brosnan et al, 2013), schizotypy (Russell-Smith et al, 2013), and degree subject (Manson & Winterbottom, 2012) to name some examples. Strutt et al (2014) found that individuals with higher levels of trait anxiety scored high in systemising and low in empathising,

whereas those who were less anxious, demonstrated balanced tendencies in both domains. Another study has shown that a jumping to conclusions bias resulted in greater empathising and reduced systemising compared to a non-jumping to conclusions group (Brosnan et al, 2013). The study into schizotypy, conducted by Russell- Smith et al (2013) has provided null results, and in relation to degree subject, Manson and Winterbottom (2012) found that (i) males score more highly in systemising and females score more highly in empathising, (ii) scientists score more highly in systemising and artists score more highly in empathising, and (iii) individuals' scores on empathising and systemising were better predictors of degree subject than gender.

2.5 Sensory Processing Sensitivity

Sensory processing refers to the way in which an individual detects, regulates, interprets and responds to sensory stimuli, and can include both physiological and behavioural components (Ben-Avi et al, 2012). The functioning of the nervous system and structural changes relate to the physiological aspect, and the individual's ability to regulate reactions to stimuli adaptively to the environmental requirements, relates to the behavioural aspect. Atypical sensory processing may be expressed by hypersensitivity (the tendency to have a negative reaction to a sensory input that is commonly considered harmless) or hyposensitivity (a decreased sensitivity to stimuli in the environment) to sensory stimuli. This is dependent on the neurological threshold for sensory stimuli. An individual with a low neurological threshold requires low intensity stimuli to react, whereas an

individual with high neurological threshold need high intensity stimuli or takes longer to react to the same stimuli (Ben-Avi et al, 2012).

Sensory processing sensitivity (SPS) is considered to be an innate trait which is characterised by greater sensitivity to social and environmental stimuli (Acevedo et al, 2014; Jagiellowicz et al, 2016). It is measured through a 27-item questionnaire known as the Highly Sensitive Person Scale (HSPS; Aron & Aron, 1997; Appendix 10). The scale was initially devised in order to conceptualise SPS as a unitary factor, however, a psychometric evaluation of the HSPS was conducted by Smolewska et al (2006) who identified that the scale comprises of three forms of sensitivity. These include: (i) Ease of Excitation, (ii) Aesthetic Sensitivity, and (iii) Low Sensory Threshold. Individuals who score high in ease of excitation are prone to being mentally overwhelmed by both internal (pain, hunger) and external (light, noise) stimuli, whereas a high score in aesthetic sensitivity is related to greater awareness and appreciation of beauty, and individuals scoring high in low sensory threshold are more likely to feel unpleasantly aroused by external stimuli such as bright lights and loud noises (Smolewska et al, 2006).

Being a highly sensitivity person has both its positives and negatives, for instance, having a greater awareness and appreciation for the environment and surroundings is generally a positive experience, however it can easily be turned into a negative experience when the various stimuli become overwhelming (Bakker & Moulding, 2012). Much of the research into SPS has tended to focus on the negative aspects. In particular, research has shown links between high SPS and greater perceived stress,

along with more frequent symptoms of ill health measured by two separate self-reported measures of health (Benham, 2006). Other research has found associations between SPS and anxiety (Liss et al, 2005; Neal et al, 2002), depression (Liss et al, 2005), social phobia (Neal et al, 2002), avoidant personality disorder (Meyer & Carver, 2000), and social introversion and emotionality (Aron & Aron, 1997).

However, research into the subscales of the HSPS (Appendix 10) has found the aesthetics sensitivity subscale to be related to more positive and beneficial outcomes than the ease of excitation and low sensory threshold subscales (Ahadi and Basharpoor, 2010; Liss et al, 2008; Sobocko & Zelenski, 2015). Specifically, aesthetic sensitivity has been found to be associated with well-being and desirable personality traits, including positive affect and openness to experience, while ease of excitation and low sensory threshold were associated with neuroticism and negative affect (Sobocko & Zelenski, 2015). Similarly, Ahadi and Basharpoor (2010) have shown aesthetic sensitivity to be associated with openness to experience and conscientiousness, and Liss et al (2008) show aesthetic sensitivity to be associated with greater attention to detail and good communication - measures of the Autism Spectrum Quotient (Baron-Cohen et al, 2001). This was tested in a sample of 201 college students who completed the HSPS and measures of anxiety, depression, alexithymia (the inability to identify, describe and interpret emotional states), and autism symptoms (Liss et al, 2008).

Brain imaging studies have revealed differences in neural responses between individuals high in SPS and those low in SPS (Acevedo et al, 2014;

Aron et al, 2010; Jagiellowicz et al, 2010). During a task involving the perception of visual scenes, in which participants performed a change detection trial whereby they were instructed to indicate whether the image was the same as or different from the proceeding image (both minor and major changes in images were shown), individuals high in SPS exhibited greater brain activation in regions involved in high-order visual processing, as well as increased response times. This suggests that individuals high in SPS take longer to respond to minor, as opposed to major, changes in visual scenes, thus showing increased activation in visual attention areas as they pay closer attention to the finer details within a scene (Jagiellowicz et al, 2010). Other research has found that individuals high in SPS show little cultural differences during simple visuospatial tasks which emphasise judgements that are either typically easier for Americans (context independent) or typically easier for Asians (context dependent), whereas those low in SPS show strong cultural differences (Aron et al, 2010). Generally, East Asian cultures show interdependence of ideas and practices and Americans show independence of ideas and practices. These cultural differences also apply to performance on simple perceptual judgments. For example, people from East Asian cultural contexts perform better on tasks with interdependent (relative or context dependent) demands, and people from Western cultural contexts perform better on tasks with independent (absolute or context independent) demands (Kitayama et al, 2003). The study conducted by Aron et al (2010) consisted of 10 European-Americans and 10 East Asians who completed a task which involved judging stimuli that depicted a vertical line inside a box. Participants had to identify whether

each line and box combination matched the proportional scaling of the previous one (absolute or context independent), or whether each line matched the previous line despite the size of the box (relative or context dependent). Thus, it was shown that individuals high in SPS process sensory information more carefully and thoroughly, and are more responsive to the actual stimuli and less affected by the cultural context than individuals low in SPS (Aron et al, 2010).

One particular neuroimaging study investigated SPS in relation to the perception of other people's emotions (Acevedo et al, 2014). The experiment consisted of participants viewing images of their romantic partners, as well as strangers, displaying facial expressions that were either positive (happy), negative (sad) or neutral. Findings revealed stronger activations in brain regions concerned with awareness, integration of sensory information, empathy (including a region of the mirror neuron system), and action planning in individuals scoring higher in SPS. It was also found that the stronger activations were in response to the images of individuals displaying positive emotions, and the images of their romantic partners. Such research suggests that highly sensitive individuals have greater awareness and are more in tune with environmental stimuli and others' needs and emotions (Acevedo et al, 2014).

2.6 Chapter Summary

Embodied cognition is a topic in the cognitive sciences which assumes that the physical body, including the body's form and structure, sensory and motor systems, and emotions, play an important role in

influencing psychological processes (including sensation, perception, attention, learning and memory) (Glenberg, 2010). The discovery of mirror neurons which suggests that the same neurons in the brain fire during the performance of a movement, as well as the observation of the same movement, has provided support for embodied cognition (Di Pellegrino et al, 1992). Furthermore, mirror neurons have been linked to empathy (Gallese, 2001), as research shows overlapping brain region during the *execution* of an action, emotion or sensation, and the *observation* of the same action, emotion or sensation (Jabbi et al, 2007; Morrison et al, 2004; Ochsner et al, 2008; Singer et al, 2004; Wicker et al, 2003). Empathy can be split into two main types, namely emotional empathy and cognitive empathy (Shamay-Tsoory, 2011). Research shows that mirror neurons may be involved in both emotional empathy (Kaplan & Iacoboni, 2006; Pfeifer et al, 2008; Shamay-Tsoory et al, 2009) and cognitive empathy (Gazzola et al, 2006). Baron-Cohen (2002) has proposed an empathising-systemising theory which posits that there are two opposing cognitive profiles, the male brain and the female brain. It is assumed that an individual is significantly better at either empathising than systemising, or vice versa. However, research both supports (Baron-Cohen et al, 2003; Baron-Cohen & Wheelwright, 2004; Jarrold et al, 2000) and refutes this (Carroll & Yung, 2006; Lawson et al, 2004; Ling et al, 2009; Russell- Smith et al, 2013). Another innate trait that provides support of embodied cognition is SPS, which is characterised by greater sensitivity to social and environmental stimuli (Acevedo et al, 2014; Jagiellowicz et al, 2016). This trait is seen to have both positive and negative outcomes (Bakker & Moulding, 2012), and a key finding has shown

SPS to be related to increased empathy (including activation of a region of the mirror neuron system) (Acevedo et al, 2014). A link between embodiment and aesthetics has been proposed by Freedberg and Gallese (2007) who suggest that a fundamental and universal aspect concerning aesthetic response to visual artwork (paintings and sculptures) involves the activation of embodied mechanisms, including the simulation of actions, emotions and corporeal sensations. This is central because the thesis focuses on embodiment and aesthetics through empathy, SPS, creativity and colour perception. Therefore, the next chapter will introduce mechanisms of creativity and aesthetics.

2.7 Chapter Highlights

- According to the embodiment theory, the body has an influence on psychological processes.
- The discovery of mirror neurons has provided evidence in support of embodied cognition.
- A direct link between mirror neurons and empathy was proposed in the shared manifold hypothesis.
- Embodied simulation plays a role in the way in which individuals empathise with others, as the individual's own internal representations of others' bodily states are activated via the perception of actions, emotions, or sensations which are associated to various social stimuli.
- The activation of the same brain region during the execution of an action, emotion or sensation, and the observation of the same action, emotion or sensation, allows the individual to understand and empathise with others.

- Empathy may be viewed as being an emotional construct which involves sensing the feelings of others, and it could be viewed as being a cognitive construct which involves understanding the perspective of others.
- It has been proposed that there are two opposing cognitive profiles, the male brain and the female brain, whereby an individual is significantly better at either empathising than systemising, or vice versa.
- Sensory processing sensitivity (SPS) is considered to be an innate trait which is characterised by greater sensitivity to social and environmental stimuli.
- SPS can be measured by the Highly Sensitive Person Scale (HSPS) which comprises of three subscales: (i) Ease of Excitation, (ii) Aesthetic Sensitivity, and (iii) Low Sensory Threshold.
- Being a highly sensitivity person has both its positives and negatives, and much of the research into SPS has tended to focus on the negative aspects.
- Research into the subscales of the HSPS has found the aesthetics sensitivity subscale to be related to more positive and beneficial outcomes than the ease of excitation and low sensory threshold subscales.

Chapter 3: Creativity and Aesthetics

3.1 Defining and Measuring Creativity

The general definition of creativity is bipartite, and thus usually includes the use of two criteria (Runco & Jaeger, 2012). Hence, creativity can be defined as an act (the ability to produce something) or an idea/thought that is in some way novel (original, unusual, unexpected, unique) and appropriate (effective, useful, beneficial, fit for purpose, adaptive concerning task constraints) (Mumford & Gustafson, 1988; Runco & Jaeger, 2012; Sternberg, 1999). There are a number of factors such as drive for originality, independence, devotion to work, and flexibility, which are thought to be related to the process of creativity (Hayes, 1989). Although creativity is usually associated with artists who create works through painting, dancing, writing, and music, to name but a few (Zaidel, 2013), individuals that do not deal in the arts may also be highly creative in other human endeavours such as science, medicine, economics/mathematics, teaching, politics and business (Zaidel, 2013). Therefore, the neuropsychological and neuroanatomical source of creativity within artists may not differ from that of other individuals (Zaidel, 2013). Psychological research into creativity only began to expand after J. P. Guilford stated in his 1950 American Psychological Association presidential address that the topic deserved much more attention than it was getting (Simonton, 2000).

The four ‘P’s’ model is a way of categorising creativity research into the creative person, process, product, and press (environment) (Kaufman & Sternberg, 2007). Research into the ‘creative person’ primarily utilises two

approaches: trait theories which assume that the creative individual has certain mental abilities and attitudes (personality types, profession, life-time accomplishments), and psychometric tests which aim to quantify the mental abilities that correlate with creative individuals (such as divergent thinking tests) (Santanen et al, 2002). Research focusing on the 'creative process' has utilised stage models of the creative thinking process (such as the concept of flow and the geneplore model which suggests that when people engage in creative thinking they move through phases of (i) generation - where they construct mental representations termed pre-inventive structures, and (ii) exploration – where those pre-inventive structures are interpreted in a meaningful way), whereas research focusing on the 'creative product' investigates what causes creative products to be different from non-creative products and uses lists of creative/non-creative products as a form of assessment (such as creative achievement and creative behaviours questionnaires, as well as divergent thinking tests). Lastly, research into the 'press' perspective of creativity sees creativity as an interaction between individuals and their environment, showing some of the possible factors that affect creativity (including motivation, competition, and risk-taking) (Santanen et al, 2002).

Creativity research tends to focus on either Big-C creativity (eminent or genius level creativity, such as the work of Picasso and Einstein) or little-c creativity (everyday creativity, such as decorating a room and writing a poem) (Kaufman & Sternberg, 2007). However, Kaufman and Beghetto (2009) propose a Four C model of creativity adding to this dichotomy. The model adds two more constructs (mini-c creativity and Pro-c creativity) with

the aim of making important distinctions between various levels of creative magnitude. For instance, mini-c creativity refers to the personal and developmental aspects of creativity, such as attempting to do a new task like learning to ride a bike, and Pro-c creativity refers to a degree of creative accomplishment such as working in the profession of art or photography yet never reaching stardom (Kaufman and Beghetto, 2009).

According to a critical review conducted by Sawyer (2011), research into the cognitive neuroscience of creativity has largely utilized brain imaging techniques to investigate the brain regions involved in creativity. The three most predominant are electroencephalography (EEG), positron emission tomography (PET) and functional magnetic resonance imaging (fMRI). Findings suggest that almost all brain regions are active during different creative tasks (for example, the Alternate Uses Test: Guilford et al, 1960; and the Remote Associates Test: Mednick, 1967), with the activation of both hemispheres being roughly proportionate (Sawyer, 2011). However, because creativity is such a broad and diverse phenomenon, there are a number of alternative ways in which it can be tested. For instance, many self-report scales, performance tasks and other assessment techniques have been devised to measure some of the different aspects relating to creativity, including creative cognition, creative behaviour, creative accomplishments, creative products, and creative traits (Kaufman et al, 2008).

Some of the fairly new and recent measures of creativity include the Creative Achievement Questionnaire (CAQ; Carson et al, 2005; Appendix 4), the Biographical Inventory of Creative Behaviors (BICB; Batey, 2007; Appendix 1), the revised Creative Behavior Inventory (CBI; Dollinger, 2003),

and the Creativity Domain Questionnaire (CDQ; Kaufman, 2006). All of these employ a simple self-report format which measures creative achievement, behaviour, and self-perception (Silvia et al, 2012). The CAQ measures creative accomplishments within 10 different domains (Visual Arts, Music, Dance, Architectural Design, Creative Writing, Humor, Inventions, Scientific Discovery, Theater and Film, and Culinary Arts) with the aim of measuring Pro-c or Big-C creativity (Silvia et al, 2012). The BICB is similar to the CAQ in its behavioural approach, however instead of measuring Pro-c or Big-C creativity, it aims to assess little-c or everyday creativity. It applies a 34-item scale which covers activities such as art, crafts, creative writing, leadership, coaching, and mentorship, and asks the participant to indicate which activities they have done within the past 12 months (Silvia et al, 2012). The revised CBI is a 28-item measure that contains a four-point scale ranging from “never did this” to “did this more than five times” (Dollinger, 2003). The scale asks participants to indicate how much they have been involved in certain activities, such as, made a sculpture. The items include accomplishments in the visual, literary and performing arts, and crafts (Dollinger, 2003). The CDQ focuses on an individual’s self-concept, measuring their beliefs about their level of creativity within various domains as opposed to measuring their creative accomplishments and observable behaviours (Silvia et al, 2012). The CAQ asks people “How creative would you rate yourself in…”. Various items are then given for domains such as acting, computers, dancing, leadership, and writing (Silvia et al, 2012).

Furthermore, creativity can be measured through divergent thinking tasks. Divergent thinking (DT) is considered to be an integral component

within the creative process, thus DT tests are another common and widely used measure of creativity, specifically creative thinking (Batey & Furnham, 2006). Nevertheless, it is important to mention that DT is not synonymous with creativity; instead, it is merely thought to be an estimate (or a potential predictor) of creative problem solving (Runco, 2008). DT tasks are similar to fluency tasks in that they measure production ability in response to a constraint (Silvia et al, 2008). For example, a letter fluency task might ask for a list of as many words as can be thought of that begin with the letter P, or a semantic fluency task might as for a list of as many countries that can be thought of, a DT task might ask for a list of unusual uses for a common object such as a brick or newspaper. DT scores intend to capture the creative component or the uniqueness of ideas, whereas fluency task scores are simply based on the number of responses generated (Silvia et al, 2008). DT tasks are evaluated on fluency (the ability to produce a number of ideas for a certain problem), flexibility (the ability to see a problem from different approaches, scored by the number of different categories implied by the responses), and originality (the ability to produce unusual/unique responses) (Pásztor et al, 2015). DT tasks differ from convergent thinking tasks, such as conventional intelligence tests, which only contain one or a few correct answers (Pásztor et al, 2015).

According to Zeng et al (2011), there are several weaknesses concerning traditional DT tests, namely: (i) lack of construct validity, (ii) not testing the integrated general creative process, (iii) neglect of domain specificity and expertise, (iv) and poor predictive, ecological, and discriminant validities. Despite this, a meta-analysis of 44 studies conducted

by Kim (2008), has revealed a weak yet statistically significant correlation between DT test scores and creative achievement (r = 0.216). Furthermore, a neuroimaging study conducted by Gibson et al (2009) provides support for a relationship between divergent thinking and creativity. The experiment consisted of trained musicians and a control group matched in age, education and sex. Frontal cortical activity was measured using near-infrared spectroscopy. Findings showed greater bilateral frontal activity within musicians, as opposed to the matched controls, whist engaged in DT. The results therefore suggest that the creativity in creative individuals may be composed of enhanced divergent thinking abilities (Gibson et al, 2009).

One particular study has examined whether the same or different variables are predictors of creativity when measured through divergent thinking compared to creative expert performance (An et al, 2016). A total of 143 participants, who were college students, enrolled on psychology courses at four separate universities in South Korea, completed seven types of tests. These were measurements of (i) general intelligence, (ii) domain knowledge, (iii) creative behaviours, (iv) motivation, (v) creative personality, (vi) divergent thinking, and (vii) creative expert performance. Different constructs were found to underlie divergent thinking and creative expert performance. Specifically, general intelligence and creative personality were predictors of creativity as divergent thinking, whereas, general intelligence, domain knowledge and motivation were predictors of creativity as creative expert performance. This indicates that divergent thinking and creative expert performance are two different constructs. One particular limitation of this

study is that different colleges held different assessment criteria for the domain knowledge scores (An et al, 2016).

Another important aspect to consider in relation to creativity is imagination. According to Vygotsky (2004), imagination refers to thoughts and ideas that are not real or true, in the sense that they are not happening at that particular moment in time; imagination is the source of creative production and is therefore fundamental to every aspect of cultural life. Moreover, imagination is the mind's ability to conceive things which are not readily available to the senses; hence, when the individual imagines, the individual creates, and according to Clement (2012) this is done through a connection between the conscious and subconscious minds. The human mind can only make relationships between two or more different mental elements if they are available in the imagination due to the individuals' previous experiences, whether physical or emotional (Vygotsky, 2004). The imagination re-combines the already existing mental elements, thus making links and connections which ultimately lead to new ideas and creations (Clement, 2012).

In summary, creativity can be defined as an act, idea, or thought that is in some way novel and appropriate (Mumford & Gustafson, 1988; Runco & Jaeger, 2012; Sternberg, 1999). According to the four 'P's' model, creativity research can be categorised into the creative person, process, product, and press (environment) (Kaufman & Sternberg, 2007). Creativity research tends to focus on either Big-C creativity (eminent or genius level creativity) or little-c creativity (everyday creativity) (Kaufman & Sternberg, 2007). However, the Four C model adds mini-c creativity and Pro-c creativity with the aim of

making important distinctions between various levels of creative magnitude (Kaufman and Beghetto, 2009). Cognitive neuroscience uses brain imaging techniques to investigate the brain regions involved in creativity (Sawyer, 2011). However, self-report scales, performance tasks and other assessment techniques, including DT tasks are also used to measure creativity (Kaufman et al, 2008). Creative individuals usually produces works that can be considered as aesthetically pleasing. Therefore the domain of Neuroaesthetics will be explored.

3.2 Neuroaesthetics

Visual artists often produce objects of admiration and beauty, including paintings, drawings, sculptures, etchings, and other decorative arts and crafts resembling the profound physical expressions of the human ability to produce and appreciate aesthetics (Cela-Conde et al, 2011). The word 'aesthetics' originates from the Greek word 'aiesthesis' which relates to the senses, sensations and perception. The term was first used by a German philosopher named Alexander Gottlieb Baumgarten (1714 –1762) in a book on poetry (Brown & Dissanayake, 2009). In general, aesthetics concerns the appreciation of beauty, and can thus be defined as the appreciation of beauty within nature, however, aesthetics also relates to the arts and artworks, and concerns the knowledge and appreciation resulting from an emotional response elicited by the perception of great works of art (Brown & Dissanayake, 2009). Hence, an aesthetic experience occurs through the senses and consists of the emotional value which is placed onto objects, allowing the beholder to perceive, feel, and sense (Brown & Dissanayake, 2009). Although all cultures have engaged in, discussed, and even studied

aesthetics from a subjective, descriptive and humanistic perspective, it is neuroscientists and neuropsychologists whom have delved into the neural, biological and evolutionary aspects of aesthetic experiences, which has now become known as the field of Neuroaesthetics (Cela-Conde et al, 2011). According to Cross & Ticini (2012), the aim of neuroaesthetic inquiry should be to provide a knowledge and understanding of the way in which the artist's products may alter and affect the neurophysiology of the beholder, as opposed to merely focusing on the definition of rules and criteria concerning the benchmark of successful and beautiful works of art.

Neuroaesthetic investigations have identified that the activation of sensorimotor, emotional and cognitive mechanisms may be involved in the aesthetic experience of visual artworks (Di Dio & Gallese, 2009). Neuroaesthetics, which is a relatively new field within cognitive neuroscience (Di Dio & Gallese, 2009), is a domain which focuses on the properties of the brain as it engages in aesthetic experiences such as art, dance, music, and literature (Chatterjee, 2011). The process of many neuroaesthetic experiments usually involves the procedure of participants viewing the stimuli, appreciating their aesthetic qualities, rating their value, and formulating a response (Cela-Conde et al, 2013). Both imaging and neurophysiological techniques are mainly utilized within these experiments, including fMRI, magnetoencephalography (MEG), and EEG (Chatterjee, 2011). 'Art, like everything we do, is generated from electrical impulses passed between synapses in the brain, expressed through the body, and eventually appreciated through the senses' (Cross & Ticini, 2012:11). However, visual perception in particular is highly important, as it is involved

in the majority of aesthetic experiences (Brown & Dissanayake, 2009). The visual brain separates elements such as colour, luminance, and motion; as well as separating higher-order objects such as faces, bodies, and landscapes (Chatterjee & Vartanian, 2014). Dynamic paintings such as the work of Van Gogh evoke a subjective sense of movement and activate the visual motion area MT, also known as V5, whereas portraits activate the face area in the fusiform gyrus, and landscapes activate the place area in the parahippocampal gyrus (Chatterjee & Vartanian, 2014). Thus, this suggests that aesthetic pleasure may arise from a number of different brain structures, the perceptions of specific stimuli, and the distribution of relevant neurotransmitters in the cortex. After the initial visual analysis of a particular aesthetic stimuli, further levels of processing are undertaken; this leads to an aesthetic experience which may be based on either biological or embodied mechanisms (see Chapter 2 section 2.1 on embodied cognition) that are dependent on factors such as the individuals' interest in the artwork, the context it is in, and their prior knowledge and familiarity concerning the artwork (Di Dio & Gallese, 2009). Thus, the brain basis of an aesthetic experience is complex and has been associated with a number of different brain networks, including the reward network (Jacobsen et al, 2006; Kawabata & Zeki, 2004; Vartanian & Goel, 2004), the core emotion centres (the insula and the amygdala) (Cupchik et al, 2009; Di Dio et al, 2007), the mirror neuron system (Ticini et al, 2014), and the default mode network (DMN) (Cela-Conde et al, 2013; Vessel et al, 2012; Vessel et al, 2013). The DMN is a network of brain regions typically found to be suppressed when observers engage in externally oriented tasks (Raichle et al, 2001).

3.2.1 Previous Research on Aesthetics Experiences

Firstly, previous research on aesthetics indicates the involvement of the brain's reward network (Di Dio & Gallese, 2009). In one particular study, participants viewed different categories of paintings and were required to judge them as being either beautiful, neutral or ugly (Kawabata & Zeki, 2004). Enhanced activation was found in the medial orbitofrontal cortex whilst the participants viewed the paintings which they judged as beautiful, whereas the paintings that were judged as ugly evoked the lowest level of activation within the same brain region. However, this study only used a sample of 10 participants (Kawabata & Zeki, 2004). Even still, the results suggest a link between aesthetics and reward as the orbitofrontal cortex encodes the identity of rewards and reward outcomes, including visual appearance, taste, smell and texture (Klein-Flügge et al, 2013). Another study exposed participants to both representational and abstract paintings in three different formats: (i) original, (ii) altered (an object in the painting was moved to a different location in the painting) and (iii) filtered (a median noise filter was applied resulting in the random distribution of colour levels within a 16-pixel radius) (Vartanian & Goel, 2004). The 12 participants, 10 of which were female, were required to rate the paintings based on aesthetic preference. The fMRI findings indicated that activation in right caudate nucleus decreased in response to decreasing preference, and that activation in the bilateral occipital gyri, left cingulate sulcus, and bilateral fusiform gyri increased in response to increasing preference. From this it was concluded that the differential patterns of activation within these particular brain structures, in response to aesthetic preference, are examples of the roles in

which they play in evaluating reward-based stimuli which vary in emotional valence (Vartanian & Goel, 2004). Similarly, an fMRI study which has utilized a set of geometric shapes as stimuli, as opposed to paintings, has also provided evidence of a link between aesthetics and reward (Jacobsen et al, 2006). Aesthetic judgements were made by the participants as to whether the images were beautiful, and whether or not they were symmetric. The symmetric images were considered as more beautiful than the non-symmetric images, and aesthetic judgements activated the medial frontal cortex, the precuneus, and the ventral prefrontal cortex (Jacobsen et al, 2006). Furthermore, the left intraparietal sulcus was jointly active for both symmetry and beauty judgments, and both the beauty and complexity of the images aroused activation within the orbitofrontal cortex (Jacobsen et al, 2006).

Research also suggests that aesthetic preference is linked to the core emotion centres: the insula and the amygdala (Di Dio & Gallese, 2009). For example, an fMRI experiment conducted by Cupchik et al (2009) examined three different conditions including pragmatic, aesthetic and baseline. Within the pragmatic group participants were shown 32 representational paintings (nude, group portrait, landscape, still-life) and asked to view them in an everyday detached manner, focusing on the content and visual narrative. In the aesthetic group, participants were shown representational paintings and asked to view them in a subjective engaged manner, experiencing the mood and feelings which they evoked, whilst focusing on the colours, tones, composition, and shapes within the paintings. Finally, in the baseline group, participants were shown 16 non-representational paintings (fractal paintings

by the American gestural expressionist artist Jackson Pollock and non-fractal paintings by the Israeli scholar Dr. Tsion Avital) and asked not to engage in either pragmatic or aesthetic viewing. Within the results, both the pragmatic and aesthetic groups were compared to the baseline. This revealed activation in a distributed network including the left insula, left cingulate gyrus, left lingual gyrus, and right inferior temporal gyrus, indicating engagement in the task and mnemonic processing. Furthermore, each group was individually compared to the baseline. Activation in the right fusiform gyrus was shown when the pragmatic group was compared to the baseline, indicating object recognition and visual and spatial search, and activation in the bilateral insula was found when the aesthetic group was compared to the baseline, suggesting that the participants were emotionally engaged during the aesthetic condition (Cupchik et al, 2009).

In addition, another fMRI experiment examined a sample of 14 students with no experience in art theory (Di Dio et al, 2007). The procedure consisted of showing the participants 15 images of Classical and Renaissance sculpture differing in proportion, both original and modified (long-trunk, short-legs and short-trunk, long-legs) were shown. The test conditions included (i) observation, where the participants were required to indicate whether or not they paid attention to the image; (ii) aesthetic judgement, where they had to indicate whether or not they liked the image; and (iii) proportion judgement, which required the participants to indicate whether or not the image was in proportion. The results revealed activation of the right insula and some lateral and medial cortical areas for the original sculptures when compared to modified ones, and activation of the right

amygdala for the images judged as beautiful compared to those judged as ugly. From these findings it has been suggested that the individuals' sense of beauty is based on two distinct processes. The first being 'objective beauty', which involves the activation of sets of cortical neurons and the insula, resulting from parameters intrinsic to the stimuli, and the second being 'subjective beauty', which involves the activation of the amygdala and is dependent on the individual's own emotional experiences (Di Dio et al, 2007).

Other research supports the recently established link between embodiment and aesthetics, which implicates the involvement of the mirror neuron system. For example, a study consisting of a sample of 373 adult participants has provided support for the effect of aesthetic experience on emotional physiological responses (Tschacher et al, 2012). The participants wore electronic gloves which measured heart rate, skin conductance and locomotion whilst viewing artworks of their choice at a fine art museum. Both emotional and aesthetic responses were evaluated by the use of a customised questionnaire subsequent to the viewing. The findings indicated a significant relationship between the participants' physiological responses during the perception of artwork and their aesthetic-emotional experience of the artwork (Tschacher et al, 2012). The link between embodiment and aesthetics is also supported by the results found by Di Dio et al (2007) in the study delineated above, as the activation of the ventral premotor cortex and the posterior parietal cortex during the observation of sculptures suggests motor resonance congruent with the movements portrayed in the sculptures. Moreover, a recent study conducted by Ticini et al (2014) has demonstrated

that action priming matching the artist's painting style enhances aesthetic preference, suggesting that covert painting simulation contributes to aesthetic appreciation. Within this study, participants were primed with either a precision grip, a forced grip, or a flat hand. Firstly, they were required to paint dots (precision grip), strokes (forced grip), or place their hand palm down on the table (flat hand) to obtain and strengthen a visuomotor association. They then observed 90 pointillist-style paintings preceded by an image of the one of the three primes, which were either compatible or incompatible with the pointillist style of painting. The participants also rated the paintings on a nine-point Likert scale ranging from "I like it very much" to "I do not like it at all" (Ticini et al, 2014).

Lastly, the DMN is shown to be related to aesthetics in a recent fMRI study conducted by Vessel et al (2013). The study found that regions of the DMN were positively activated on the highest-rated trials in a task involving rating images of unfamiliar artworks. The ratings were based on the participants' individual tastes and on how much the artwork "moved" them. The findings suggest that certain artworks may be so well matched to an individual that it relates to their sense of self through the DMN, giving them a sense of being "moved" or of being "touched from within", which other external stimuli do not normally get (Vessel et al, 2013). The DMN is a network of brain regions typically found to be suppressed when observers engage in externally oriented tasks (Raichle et al, 2001). It is inversely correlated with attention to external stimuli (Shulman et al, 1997; Buckner et al, 2008) and is associated with thinking of the past and imagining the future (Buckner & Vincent, 2007). Brain regions of this network include: the medial

prefrontal cortex, the posterior cingulate cortex, the temporo-parietal junction, the lateral temporal cortex, the superior frontal gyrus, and the hippocampus (Vessel et al, 2013). Thus, it is possible that aesthetic experiences involve an internal orientation evoked by an external stimulus (Vessel et al, 2013). Consistent with this, it was demonstrated in another fMRI study that the DMN was actively engaged during the viewing of paintings whilst participants explicitly focused on internal thoughts and emotions (Vessel et al, 2012). This was apparent for the viewing of artworks which were rated as being the "most moving", whereas the artworks which were given lower ratings exhibited non-differential activity in the brain regions associated to the DMN (Vessel et al, 2012). Moreover, other than fMRI findings, MEG neural responses have also been examined in relation to aesthetics in research conducted by Cela-Conde et al (2013). The findings revealed different neuronal patterns for an initial exposure to artwork used as stimuli (250 – 750 ms) compared to a delayed exposure to the artwork (1000 – 1500 ms). Both beautiful and non-beautiful stimuli were shown according to the participants' own judgements. The latter (delayed) response corresponded to frontal, parietal, and temporal medial areas belonging to the DMN, however this only occurred within the beautiful condition and not within the non-beautiful condition (Cela-Conde et al, 2013). Thus, this suggests that the DMN is active during delayed responses to beautiful artwork.

In summary, aesthetics can be defined as the appreciation of beauty within nature and in works of art (Brown & Dissanayake, 2009). An aesthetic experience occurs through the senses and consists of the emotional value which is placed onto objects, allowing the beholder to perceive, feel, and

sense (Brown & Dissanayake, 2009). The field of Neuroaesthetics deals with the neural, biological and evolutionary aspects of aesthetic experiences (Cela-Conde et al, 2011). The activation of sensorimotor, emotional and cognitive mechanisms may be involved in the aesthetic experience of visual artworks (Di Dio & Gallese, 2009). A number of different brain networks are implicated in aesthetic experiences, including the reward network (Jacobsen et al, 2006; Kawabata & Zeki, 2004; Vartanian & Goel, 2004), the core emotion centres (the insula and the amygdala) (Cupchik et al, 2009; Di Dio et al, 2007), the mirror neuron system (Ticini et al, 2014), and the default mode network (DMN) (Cela-Conde et al, 2013; Vessel et al, 2012; Vessel et al, 2013). Aesthetic experiences differ in people depending on their level of expertise within the arts, which will thus be discussed in the next section.

3.3 Experts Compared to Laypeople

In terms of ability, experts differ from laypeople as they are equipped with a structured, specialised knowledge of their area of expertise, and as knowledge systems vary in degrees of complexity, this may result in different aesthetic processing (Jacobsen, 2010). Hence, experts have been shown to process aesthetic experiences differently from laypeople, even at the neuronal level. For example, it was demonstrated in an fMRI experiment that expert dancers in either classical ballet or capoeira, as opposed to non-expert dancers, show stronger activation in various brain regions when observing other dancers performing in the same style (Calvo-Merino et al, 2005). Similarly, when compared to a group of laypeople matched for age and gender, professional pianists exhibited stronger activation of the same cortical network when listening to piano melodies as when performing the

musical actions on the keyboard (Bangert et al, 2006). Such research suggests that the mirror mechanism is strengthened through expertise and experience (Gallese, 2010).

Other research has examined experts compared to laypeople whilst engaged in aesthetic performance, showing clear differences between the two. Specifically, a study conducted by Bhattacharya and Petsche (2005) utilized EEG to examine whether mentally composing drawings of their own choice produces different electrical activity within artists and laymen. Synchronization differences were found between the two groups, and it was thus concluded that the higher synchrony in the low-frequency band, within the group of artists, may be a result of advanced long-term visual art memory and extensive top-down processing (Bhattacharya & Petsche, 2005). Moreover, another study which has employed a similar method, using EEG to examine both artists and non-artists whilst they undertake drawing tasks, has also found differences between the two (Kottlow et al, 2011). Specifically, artists compared to non-artists exhibited decreased power (the amount of energy per unit within a given frequency) primarily in the upper alpha frequency ranges during drawing tasks, suggesting that this is a reflection of enhanced semantic memory performance and object recognition processes within the artists (Kottlow et al, 2011). In addition, Chamberlain et al (2014) examined 44 graduate and postgraduate art students and non-art students who were instructed to complete drawing tasks during an fMRI experiment. The findings show increased grey matter density in the left anterior cerebellum and the right medial frontal gyrus, suggesting that observational drawing ability relates to changes in structures pertaining to

fine motor control and procedural memory. The study also found a correlation between artistic training and increased grey matter density in the right precuneus suggesting that artistic training is associated with enhanced structures pertaining to visual imagery (Chamberlain et al, 2014). It should be noted that all of the above studies suffer from fairly small sample sizes.

Furthermore, one particular study conducted by Bhattacharya and Petsche (2002) has focused on the differences between creative individuals and laymen during an aesthetic viewing. The study examined the differences between artists and non-artists via the means of EEG phase synchrony analysis, and found significant differences during the performance of visual perception and imagery of paintings. Specifically, participants carried out two tasks, namely looking at slides of paintings projected onto a white wall and imagining each painting just shown before. Artists showed higher phase synchrony in both the high frequency beta and gamma bands during perception of paintings, and phase synchrony was mostly enhanced during imagery in the low frequency bands (mainly delta). During both tasks there were strong decreases in the phase synchrony of alpha, predominately in the artists. Artists also showed more synchrony in the right hemisphere whilst non-artists showed less significant hemispheric asymmetry. These findings suggest that artists showed enhanced synchrony in the high frequency band because of their superior binding abilities of several visual features, while the enhanced synchrony in the low frequency band may be related to their highly developed long-term visual memory of imagery (Bhattacharya & Petsche, 2002).

Lastly, art expertise has been investigated in relation to emotion-eliciting contemporary artworks and a control set of pictures from the International Affective Picture System (IAPS) (Leder et al, 2014). Within this study, participants' aesthetic and emotional responses were assessed via facial electromyography (EMG) and self-reported rating of valence, familiarity and liking. The findings revealed differences between experts and non-experts in relation to emotionally-valenced art, specifically showing less extreme valence ratings and corrugator supercilii (the frowning muscle) activations within the group of experts; they also liked the negative artworks more than the non-experts. However, the study found that this was also the case for the control set of (IAPS) pictures, thus implying that art experts show general processing differences for visual stimuli (Leder et al, 2014).

In summary, experts have been shown to process aesthetic experiences differently from laypeople, even at the neuronal level. Research suggests that the mirror mechanism is strengthened through expertise and experience (Gallese, 2010), as stronger activations in various brain regions are shown in experts whilst observing others perform and also whilst performing themselves (Bangert et al, 2006; Calvo-Merino et al, 2005). Other research suggests that the brain activity of artists may differ to that of laypeople due to advanced long-term visual art memory and extensive top-down processing (Bhattacharya & Petsche, 2005), and also because of enhanced semantic memory performance and object recognition processes within the artists (Kottlow et al, 2011). Furthermore, differences have been found in relation to observational drawing ability, and it has been shown that artistic training is associated with enhanced structures pertaining to visual

imagery (Chamberlain et al, 2014). Artists have also shown differences suggesting that they have superior binding abilities of several visual features and a highly developed long-term visual memory of imagery (Bhattacharya & Petsche, 2002). Moreover, art experts compared to non-experts show general processing differences for visual stimuli (Leder et al, 2014).

3.4 Chapter Summary

This chapter has reviewed some of the literature on creativity and aesthetics, particularly neuroaesthetics. Creativity is the ability to produce something, or to have a thought or idea, that is both novel and appropriate (Mumford & Gustafson, 1988; Runco & Jaeger, 2012; Sternberg, 1999). Creativity is apparent in many human endeavours, and is not just restricted to the arts (Zaidel, 2013). Research into creativity can be categorised into the creative person, process, product, and press (environment) (Kaufman & Sternberg, 2007). Research tends to focus on either Big-C creativity (eminent or genius level creativity) or little-c creativity (everyday creativity) (Kaufman & Sternberg, 2007). While cognitive neuroscience utilizes brain imaging techniques to investigate the brain regions involved in creativity (Sawyer, 2011), other research applies self-report scales, performance tasks and other assessment techniques (Kaufman et al, 2008), including DT tasks which measures creative thinking (Batey & Furnham, 2006). This chapter then went on to review the literature on neuroaesthetics which focuses on the properties of the brain as it engages in aesthetic experiences such as art, dance, music, and literature (Chatterjee, 2011). An aesthetic experience occurs through the senses and consists of the emotional value which is placed onto objects, allowing the beholder to perceive, feel, and sense

(Brown & Dissanayake, 2009). The brain basis of an aesthetic experience is complex and has been associated to a number of different brain networks, including the reward network (Jacobsen et al, 2006; Kawabata & Zeki, 2004; Vartanian & Goel, 2004), the core emotion centres (the insula and the amygdala) (Cupchik et al, 2009; Di Dio et al, 2007), the mirror neuron system (Ticini et al, 2014), and the default mode network (Cela-Conde et al, 2013; Vessel et al, 2012; Vessel et al, 2013). Research shows that experts process aesthetic experiences differently from laypeople (Bangert et al, 2006; Bhattacharyaa & Petscheb, 2002; Bhattacharya & Petsche, 2005; Calvo-Merino et al, 2005; Chamberlain et al, 2014; Kottlow et al, 2011; Leder et al, 2014). The next chapter focuses on colour perception and its effects, specifically looking into the biology of the perception of colour, colour perception and emotions, and the effects of colour on affect, cognition, behaviour and physiology.

3.5 Chapter Highlights

- Creativity can be defined as an act (the ability to produce something) or an idea/thought that is in some way novel and appropriate.
- The four ‘P’s’ model is a way of categorising creativity research into the creative person, process, product, and press (environment).
- Creativity research tends to focus on either Big-C creativity (eminent or genius level creativity) or little-c creativity (everyday creativity).
- The Four C model of creativity adds two more constructs (mini-c creativity and Pro-c creativity).

- Research into the cognitive neuroscience of creativity has largely utilized brain imaging techniques to investigate the brain regions involved in creativity.
- Many self-report scales, performance tasks and other assessment techniques have been devised to measure some of the different aspects relating to creativity, including creative cognition, creative behaviour, creative accomplishments, creative products, and creative traits.
- DT tests are another common and widely used measure of creativity, specifically creative thinking.
- Imagination is the mind's ability to conceive things which are not readily available to the senses; hence, when the individual imagines, the individual creates.
- Aesthetics can be defined as the appreciation of beauty within nature and the arts and artworks.
- An aesthetic experience occurs through the senses and consists of the emotional value which is placed onto objects, allowing the beholder to perceive, feel, and sense.
- Neuroaesthetics is a relatively new field within cognitive neuroscience and is a domain which focuses on the properties of the brain as it engages in aesthetic experiences such as art, dance, music, and literature.
- The brain basis of an aesthetic experience is complex and has been associated with a number of different brain networks, including the

- reward network, the core emotion centres (the insula and the amygdala), the mirror neuron system, and the DMN.
- Experts have been shown to process aesthetic experiences differently from laypeople.

Chapter 4: Colour Perception and its Effects

4.1 The Perception of Colour

The perception of colour occurs when the projection of light is transmitted through a substance, and hence a small portion of the electromagnetic spectrum (wavelengths of ~400–700 nanometres) becomes visible to the human eye in the form of colour (Fehrman & Fehrman, 2004). Humans with normal colour vision are able to differentiate between many thousands of colours through signals from three cone photoreceptors which have maximal sensitivities to long, medium and short wavelengths, thus making human colour vision trichromatic (Banaschewski et al, 2006; Solomon & Lennie, 2007). However, these photoreceptors are tuned broadly enough to respond to light spanning most of the visible spectrum (Solomon & Lennie, 2007).

Once cone receptors have absorbed light, signals from the retina pass on colour information which is then transmitted through the lateral geniculate nucleus of the thalamus (LGN) up to the primary visual cortex (V1) (Conway, 2009). The colour signals which leave V1 enable the capacity to separate changes in colour from changes in brightness, identify hue, and combine information from both eyes (Solomon & Lennie, 2007). Further processing occurs in the second visual area (V2), and then by cells located in sub-compartments (known as ‘globs’) within the posterior inferior temporal (PIT) cortex (the brain region encompassing area V4 and areas immediately anterior to V4). The processing of colour then happens within the inferior temporal (IT) cortex including cytoarchitectonic area TE (Conway, 2009).

4.2 Colour Perception and Emotions

Various research suggests that a person's feeling and emotions may alter their perception of colour (Barrick et al, 2002; Fetterman et al, 2011; Sherman et al, 2012). For example, depression has been shown to impair colour perception in a study conducted by Barrick et al (2002). The study consisted of a sample of 120 inpatients (patients in a state-supported mental health facility) and outpatients (patients who were under treatment by a psychiatrist in a private practice) with depression. Colour sensitivity was assessed via questionnaire. Findings demonstrate that colour sensitivity correlates with depression (Barrick et al, 2002).

On the other hand, research shows that negative emotions may enhance colour discrimination for the colours associated to that particular emotion. Specifically, priming for anger, as opposed to sadness, led participants to be more likely to perceive ambiguously coloured stimuli (degraded colours) as being the colour red (Fetterman et al, 2011). Furthermore, inducing anger within the participants, through noise blasts heard over headphones, also led them to be more likely to perceive the colour red as opposed to blue in ambiguous coloured stimuli (Fetterman et al, 2011). In addition, the white equals purity association was tested by Sherman et al (2012) whom found that individuals that were able to make subtle greyscale discriminations, whereby they had to detect faint grey stimuli set against white backgrounds, were more sensitive to disgusting stimuli. Moreover, individuals who were more sensitive to disgust, had enhanced ability in detecting variations from white after they had viewed disgusting images, suggesting that greater sensitivity to disgust enhances

the perception of impurities (Sherman et al, 2012). Overall, such research implies that physiological alterations caused by mood may produce differences in colour sensitivity, suggesting that alterations in neurological function from changes in mood/emotion, may alter retinal or brain functioning as well as perception and interpretation of retinal input (Barrick et al, 2002).

4.3 The Effects of Colour

The perceptual stimulus of colour is a ubiquitous human trait. The purposes of colour are often considered in relation to aesthetics, however the effects of colour on human beings has been widely studied and it is evident that colour is imbued with meaning and can profoundly influence an individual's affect, cognition, and behaviour (Elliot & Maier, 2014). For example, Cheng et al (2009) show that customers feel more aroused and pleasant whilst shopping on an online store with warm colours. Other research has shown warm coloured lighting enhances short-term memory and problem solving (Knez, 2001), and Labrecque & Milne (2012) show that purchase intent is effected by colour induced brand personality. Furthermore, various research into the psychology of colour has demonstrated that colour is related to an individual's feelings and emotions in terms of associations (Clarke & Costall, 2008; Kaya & Epps, 2004; Terwogt & Hoeksma, 1995; Wexner, 1954). For example, research has found that the colour orange is associated with the positive mood of excitement and the negative moods of upset and distress (Wexner, 1954), and other research has shown that the colours which are linked with happiness and other positive emotions are white, yellow and orange (Clarke & Costall, 2008). According to Terwogt & Hoeksma (1995), yellow is associated with

happiness even though it is liked less than other colours such as blue, red, green, white and black. In addition, principal hue colours (red, yellow, green, blue, and purple) have been found to have more positive colour-emotion associations compared to intermediate (yellow-red, green-yellow, blue-green, purple-blue, and red-purple), and achromatic (white, grey, and black) shades (Kaya & Epps, 2004).

Moreover, it is thought that cool colours are calming and sedative, whereas warm colours elicit more dynamic feelings and emotions (Clarke & Costall, 2008). Based on Goldstein's (1942) notion which suggests that there are differences between warm colours (such as yellow, orange and red) and cool colours (such as purple, blue and green) in terms of psychology, physiology and performance, much research has tended to focus on comparing the two (Akers et al, 2012; Dijkstra et al, 2008; Hatta et al, 2002; Kuller et al, 2009; Mehta & Zhu, 2009; Meier et al, 2012; Stone & English, 1998; Stone, 2001; Stone, 2003; Yildirim et al, 2007), however this has generated mixed results (some of which will thus be discussed in the next paragraphs) making it unclear as to whether warm colours or cool colour enhance or reduce performance and arousal. Therefore, it is evident that within different contexts and situations, colours can hold different meanings and associations, which consequently may have a different impact upon the individual's thoughts, feelings and behaviours during a specific time and place (Elliot et al, 2007).

For instance, one study has found the colour green to be more beneficial to exercise than the colours red or grey (Akers et al, 2012). Specifically, a total of 14 participants completed five-minute cycling tasks of

moderate intensity whilst watching a video of a cycling course through natural scenery (shown in green, red or grey). Both mood disturbance and ratings of perceived exertion were lower after watching the video in green compared to red or grey, and feelings of anger were higher after watching the video in red compared to green or grey (Akers et al, 2012). Another study has shown that individuals walked faster to a dating interview when perceiving the colour red as opposed to blue, however walking speed decreased with the colour red when the participants were approaching an interview on intelligence (Meier et al, 2012). Within the study, participants were told that there were several interviewers and were shown a picture of the person (of the opposite sex, rated as attractive in a pilot study) who would be interviewing them later. The picture was of the head and shoulders of the interviewer, wearing either a red or blue t-shirt. Following this, participants were taken to the doorway of the initial room and were told to walk down the hallway to the interview room (Meier et al, 2012). Both studies suggest that the effects of the colours perceived are indeed context dependent. Furthermore, age has been shown to affect colour emotion responses (Ou et al, 2012). Specifically, all colours were rated as less liked, less active and cooler for older observers (aged over 60 with an average of 64.8 years) compared to younger observers (ages ranging from 20-30 with an average of 24.5 years) within two experiment examining single colours and colour pairs (Ou et al, 2012). Other research shows that humans use colour for evaluating food (Foroni et al, 2016), specifically showing that the more red brightness that is present in food images, the greater the arousal they elicit. Indicating that humans are more motivated by food with more

reddish nuances, as arousal is a proxy for motivational value toward an object, particularly food (Foroni et al, 2016).

Other research demonstrates colour to have an impact on physiological reactions (Kuller et al, 2009; Tsunetsugu et al, 2005). Kuller et al (2009) carried out three experiments, one involving a colourful room (the walls were covered with four different kinds of wallpapers with strong colours and patterns, mostly in red, yellow, and white) and a grey room, and the other two involving a red room and a blue room. The participants' mood and heart rate were measured whilst performing various tasks. It was found that strong colours, including red, caused a slowing of heart rate. This was more extreme in introverts and those who already reported being in a negative mood, and thus, had a greater effect on their level of performance which was measured through writing a story about what the room made them think about. This was scored for number of words. Performance was also measured by proof reading and correcting a lengthy text (Kuller et al, 2009). A limitation of this study is that it lacks ecological validity (Kuller et al, 2009). Another study examined two living-rooms with different designs, one ordinary designed room with plain white walls, and another room with visible brown posts and beams (Tsunetsugu et al, 2005). A small sample was used consisting of 15 males. Participants' cerebral blood flow, pulse rate and blood pressure were measured during 90 seconds sat in the rooms. The physiological measures revealed participants to be more calm and relaxed in the ordinary room, whereas they had a more active and aroused state in the second room. Participants were then asked to evaluate the room using two 13-point scales along the dimensions of comfortable-uncomfortable and

restful-restless. However, no significant differences were found in their self-reported evaluations of their emotional states (Tsunetsugu et al, 2005). Thus, the physiological effects of colour and room design are apparent whether or not this is known to the individual himself.

4.4 Chapter Summary

This chapter has reviewed some of the literature on colour perception and its effects. When colour becomes visible to the human eye it is then process by the brain in the LGN, and areas V1, V2, and V4. Research shows that a person's feeling and emotions may alter their perception of colour (Barrick et al, 2002; Fetterman et al, 2011; Sherman et al, 2012). Moreover, colour is imbued with meaning and can profoundly influence an individual's affect, cognition, and behaviour (Elliot & Maier, 2014). Colour is also related to an individual's feelings and emotions in terms of associations (Clarke & Costall, 2008; Kaya & Epps, 2004; Terwogt & Hoeksma, 1995; Wexner, 1954). Both warm colours and cool colours have differing effects on individuals in terms of psychology, physiology and performance (Akers et al, 2012; Dijkstra et al, 2008; Hatta et al, 2002; Kuller et al, 2009; Mehta & Zhu, 2009; Meier et al, 2012; Stone & English, 1998; Stone, 2001; Stone, 2003; Yildirim et al, 2007). However, this seems to be context dependent. Now these areas have been reviewed, this thesis will go on to report the first experiment which investigated the effect of creativity on empathy. The purpose of the experiment was to investigate the link between creativity and empathy, which has previously been poorly explored. The study examines level of creativity in relation to level of empathy, for different types of creativity and different types of empathy. The literature that has been

reviewed so far suggests that there are differences between experts and laypeople in the processing of aesthetic experiences (Bangert et al, 2006; Bhattacharyaa & Petscheb, 2002; Bhattacharya & Petsche, 2005; Calvo-Merino et al, 2005; Chamberlain et al, 2014; Kottlow et al, 2011; Leder et al, 2014), and that the brain basis of an aesthetic experience may involve the mirror neuron system (Ticini et al, 2014), which is related to empathy (Gallese, 2001). Thus, are those who are more creative also more empathetic?

4.5 Chapter Highlights

- The perception of colour occurs when the projection of light is transmitted through a substance, and hence a small portion of the electromagnetic spectrum (wavelengths of ~400–700 nanometres) becomes visible to the human eye in the form of colour.
- A person's feeling and emotions may alter their perception of colour.
- Colour sensitivity correlates with depression.
- Negative emotions may enhance colour discrimination for the colours associated to that particular emotion.
- Colour is imbued with meaning and can profoundly influence an individual's affect, cognition, and behaviour.
- Colour is related to an individual's feelings and emotions in terms of associations.
- It is thought that cool colours are calming and sedative, whereas warm colours elicit more dynamic feelings and emotions.

- Within different contexts and situations, colours can hold different meanings and associations, which consequently may have a different impact upon the individual's thoughts, feelings and behaviours during a specific time and place.
- The physiological effects of colour and room design are apparent whether or not this is known to the individual himself.

Chapter 5: Creativity and Empathy

This chapter is the subject of a manuscript in preparation entitled 'The Creativity-Empathy Connection: How Level of Creativity Effects Level of Empathy', by Kiou J.L. and Lesk V.E

5.1 Introduction

Some of the previous introduction chapters have focused on areas which have specifically explored creativity (Chapter 3) and empathy (Chapter 2), looking into how creativity can be defined and measured, and how empathy may be related to mirror neurons and embodiment. This chapter will explore the link between creativity and empathy, investigating whether there is an effect of level of creativity on level of empathy within a sample of participants from the general population. This is important since very little research has focused on an in-depth exploration of creativity and empathy in a sample of adult participants. Therefore, the current study looks into different types of creativity in relation to different types of empathy in order to find out if (or how) they may be connected.

Creativity, 'the ability to produce work that is both novel (i.e., original, unexpected) and appropriate (i.e., useful, adaptive concerning task constraints)' (Sternberg, 1999:3), encompasses many areas of everyday life. As does empathy, which can generically be defined as 'the capacity to understand and respond to the unique affective experiences of another person' (Decety & Jackson, 2006: 54). To date, research has not yet provided a thorough exploration into the link between creativity and empathy as only a few studies have investigated this (Carlozzi et al, 1995; Kalliopuska, 1989; Kalliopuska, 1991; Rabinowitch et al, 2013). Thus, the

current experiment aims to address this issue through examining different types of creativity in relation to the different types of empathy. Both are complex and multifaceted phenomena. For example, recent neuroscientific evidence indicates that empathy may comprise of two separate neural systems, one based on emotional processing (sensing the feelings of others) and the other based on cognitive processing (understanding the perspective of others) (Shamay-Tsoory, 2011). Moreover, there is currently no evidence suggesting a distinct cerebral localization concerning creativity; that is, almost all brain regions are active during different creative tasks, with the activation of both hemispheres being roughly proportionate (Sawyer, 2011). Nevertheless, certain evidence regarding frontotemporal dementia (FTD), suggests that the frontal lobes and their inhibitory interactions concerning the temporal, occipital, and parietal lobes, may play an important role in creativity, while dysfunctional or lesioned frontal lobes (including conditions such as depression, anxiety and Wernicke's aphasia) have been hypothesized to block creative drive (Jung & Haier, 2013). Thus, with findings from brain imaging studies it is difficult to infer that the two (empathy and creativity) may be connected.

However, as the work produced by artists is often able to evoke feelings of empathy within its spectators, it is perhaps appropriate to assume that the artists themselves may be inclined to feel and understand empathy at a greater level than the average individual. Especially if they are aspiring to portray it through their work, which is often the case, since it is deemed that 'the value of art lies at least largely in the value of its expression of emotion' (Neill, 2003:442). Furthermore, although this specific area of

research is novel, a link between creativity and empathy has already been assumed, and based on Moreno's theory of spontaneity-creativity (1955), it has been suggested that a deeper look into the relationship between creativity and empathy (in the form of role reversal) is required (Yaniv, 2011).

Although the current study does not look into empathy in the form of role reversal, it does examine both emotional and cognitive empathy (taken together and separately). Various behavioural assessment techniques are used to measure the different aspects of creativity, including creative cognition, creative behaviour, creative accomplishments, creative products, and creative traits (all from Kaufman et al. 2008). This study has specifically chosen to focus on creative achievement, creative behaviours, and creative cognition (through a divergent thinking task). Previous research has found that individuals who experience extreme and intense emotions regularly, tend to score higher in creative capacity (Ceci & Kumar, 2015). Furthermore, affective engagement (referring to the extent to which an individual is open to the full breadth and depth of their emotions) was found to be a predictor of artistic creativity (Kaufman, 2013). Hence, since individuals who engage in emotions more strongly and more often, are shown to be more artistic and creative, it is hypothesised that individuals who are more creative will show higher levels of empathy.

5.2 Method

5.2.1 Participants

A total of 39 individuals, including both males and females of the age of 18 and over, participated in the study.

5.2.2 Design

A within-subjects design was utilised whereby all participants were exposed to the same conditions. The data were analysed through a General Linear Model. All measures were standardised.

5.2.3 Materials

5.2.3.1 Self-reports

Biographical Inventory of Creative Behaviours (BICB; Batey, 2007; Appendix 1)

The BICB is a measure of the number of creative behaviours which the participant has conducted within the past 12 months. This specific self-report consists of 34 items of creative behaviours (e.g. Choreographed a dance, Composed a poem). The participant was simply required to place a cross (X) next to the items which applied to them.

Creative Achievement Questionnaire (CAQ; Carson et al, 2005; Appendix 4)

The CAQ is a measure of creative accomplishments within 10 different domains: the Visual Arts (painting, sculpture), Music, Dance, Architectural Design, Creative Writing, Humour, Inventions, Scientific Discovery, Theatre and Film, and Culinary Arts. Each of the 10 domains consists of eight items which carry differing (cumulative) weights. Participants were required to place a check mark next to the items which applied to them; and for the items that were marked with an asterisk, the

participants were asked write the number of times that these sentences applied to them, if at all.

Interpersonal Reactivity Index (IRI; Davis, 1983; Appendix 5)

The IRI is a measure of both cognitive and affective/emotional empathy containing four subscales: perspective taking (cognitive), fantasy (cognitive), empathic concern (emotional/affective), and personal distress (emotional/affective). This questionnaire also encompasses a five point Likert scale which ranges from 'Does not describe me well' to 'Describes me very well' (A, B, C, D, E). There are a total of 28 statements and participants were required to indicate how well each of the statements describes them by choosing the appropriate letter and writing it next to the statement.

Toronto Empathy Questionnaire (TEQ; Spreng et al, 2009; Appendix 9)

The TEQ is a fairly recently developed questionnaire which was designed to measure empathy primarily as an emotional process. It encompasses a five point Likert scale ranging from 'Never' to 'Always' (Never = 0; Rarely = 1; Sometimes = 2; Often = 3; Always = 4) and a list of 16 statements whereby participants write the most appropriate number as their answer next to each of the statements.

5.2.3.2 Test of Cognition

Alternate Uses Test, Form B Test Booklet (AUT; Guilford et al, 1960; Appendix 6)

The AUT is a measure of divergent thinking ability. Participants completed *form B test booklet* which comprised of two parts. Each part

contained three items consisting of a common object, and each object had a common use which was stated. Participants needed to list as many as six other (alternative) uses for which the object, or parts of the object, could serve. Four minutes was allowed per part.

5.2.4 Procedure

The experiment was conducted in an experimental cubicle at the University of Bradford, Division of Psychology. On arrival, participants provided informed consent. Participants were then given the Alternate Uses Test, form B test booklet (Guilford et al, 1960; Appendix 6). This consisted of two parts with a time limit of four minutes per part. Following this were the empathy questionnaires: the Toronto Empathy Questionnaire (Spreng et al, 2009; Appendix 9) and the Interpersonal Reactivity Index (Davis, 1983; Appendix 5). Last to be completed were the creativity questionnaires: the Creative Achievement Questionnaire (Carson et al, 2005; Appendix 4) and the Biographical Inventory of Creative Behaviours (Batey, 2007; Appendix 1) respectively. More challenging tasks were presented to the participants first as they required more attention and concentration. Ethical approval was granted from the Chair of the Humanities, Social and Health Sciences Research Ethics Panel, University of Bradford.

5.3 Results

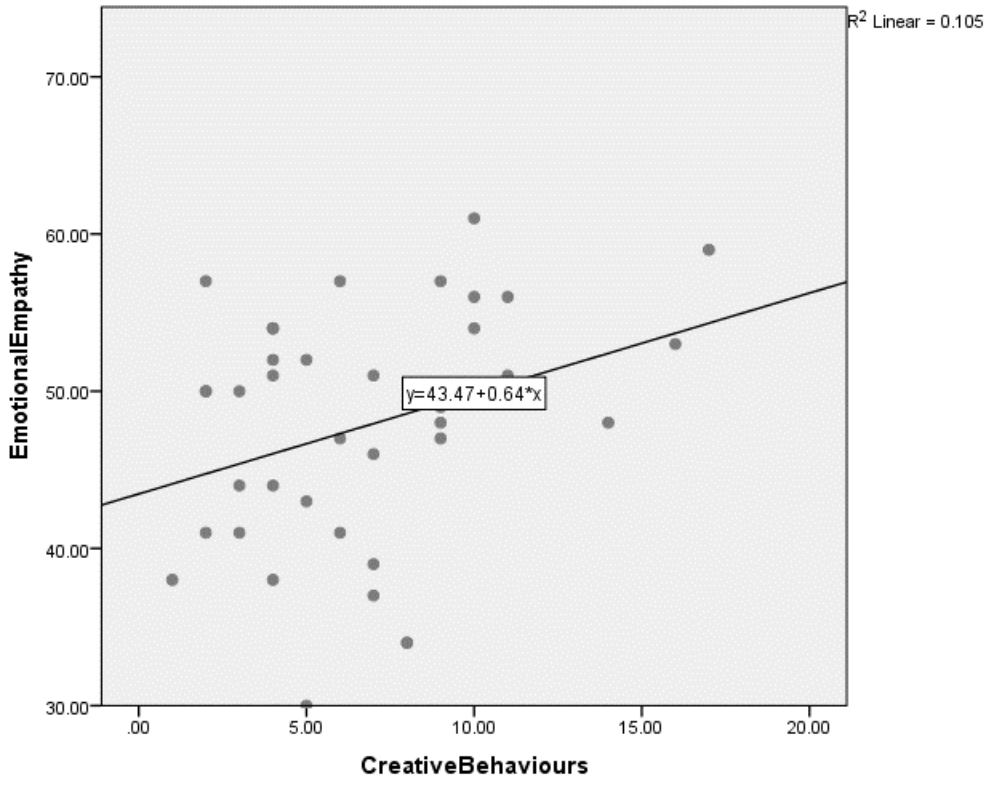
The intention of the present experiment was to investigate the link between creativity and empathy. This was done specifically by examining the effect of level of creativity on level of empathy, and exploring the different

types of creativity and empathy that are related to one another. See Table 1 for the descriptive statistics.

Table 1: Means and Standard Deviations for each Variable

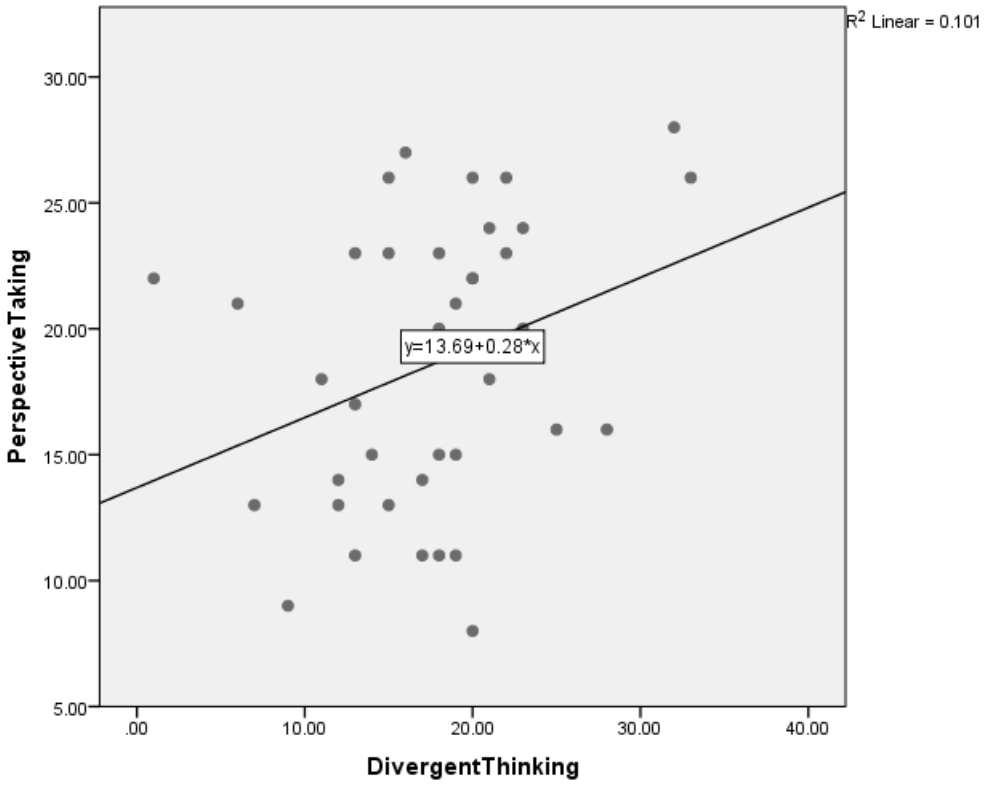
Variable	***Name of Test***	***Mean***	***SD***	***Range (Actual scores)***	***Range (Possible scores)***
Creative Achievement	Creative Achievement Questionnaire (CAQ; Carson et al, 2005)	10.26	8.13	2-36	0->280
Creative Behaviours	Biographical Inventory of Creative Behaviours (BICB; Batey, 2007)	6.77	3.86	1-17	0-34
Divergent Thinking	Alternate Uses Test, Form B Test Booklet (AUT; Guilford et al, 1960)	17.51	6.41	1-33	0-36
Emotional & Cognitive Empathy	Interpersonal Reactivity Index (IRI; Davis, 1983)	71.10	14.35	35-97	0-112
Emotional Empathy	Toronto Empathy Questionnaire (TEQ; Spreng et al, 2009)	47.79	7.60	30-61	0-64

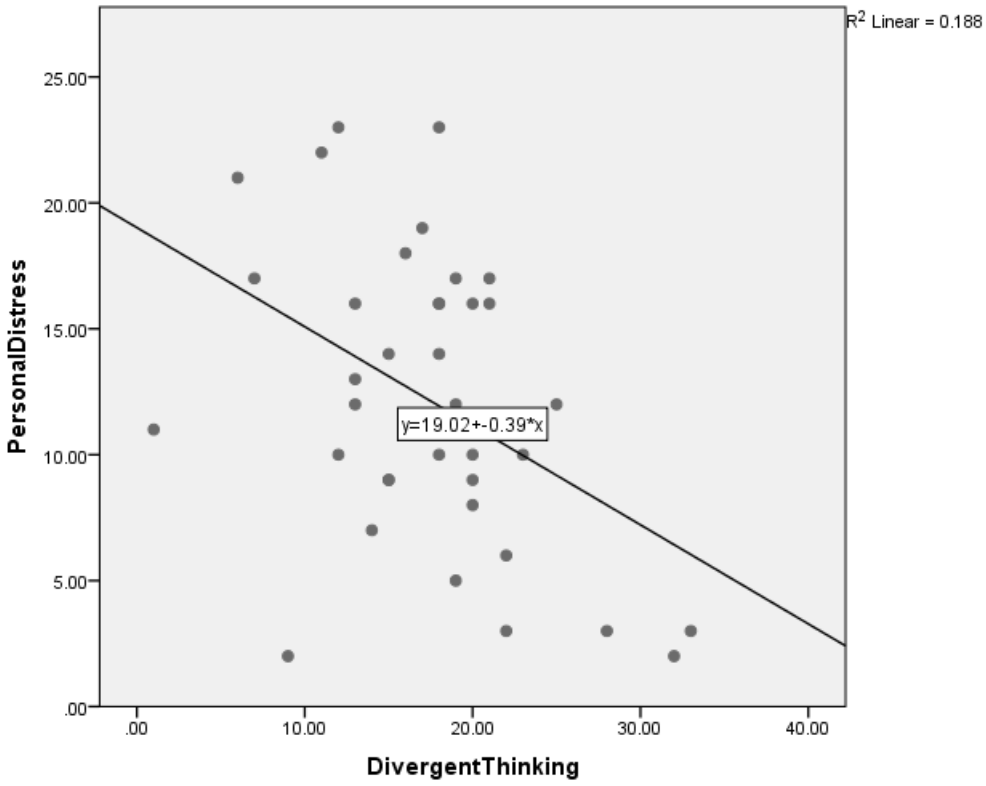
Three separate univariate general linear models (GLM) were conducted with the dependent variable being the measure of emotional empathy (TEQ), and the measures of creativity (CAQ, BICB, AUT) being the covariate in each analysis. The analyses revealed that there was no statistically significant difference in either emotional empathy (TEQ) based on creative achievement (CAQ) or divergent thinking (AUT) (N.S). However, a significant difference was shown in emotional empathy (TEQ) based on creative behaviours (BICB), ($F(1, 37) = 4.36$, $p < 0.05$, $h_p^2 = 0.11$). See Figure 1.

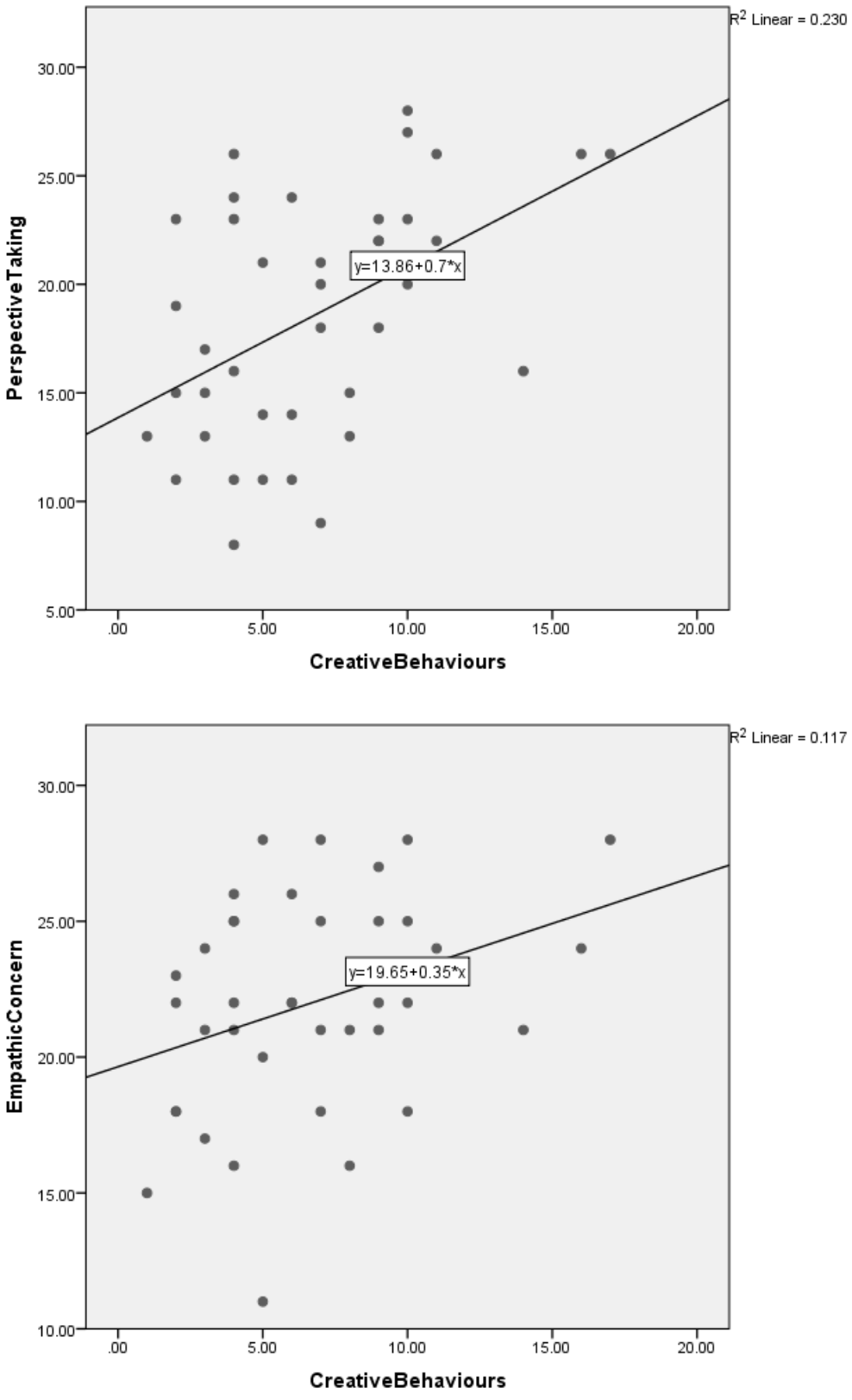


<u>Figure 1:</u> Scatterplot depicting the significant relationship between creative behaviours and emotional empathy

The total score of emotional & cognitive empathy (IRI) was submitted to a univariate ANOVA with creative achievement (CAQ) as a covariate. The same was carried out with divergent thinking (AUT) as the covariate, and then again with creative behaviours (BICB) as the covariate. No significant difference was found in the total score of emotional & cognitive empathy (IRI) based on creative achievement (CAQ) (N.S), divergent thinking (AUT) (N.S), or creative behaviours (BICB) (N.S). Exploratory analysis was used to further analyse the subscales of the measure of emotional & cognitive empathy (IRI) (these included: perspective taking (cognitive), fantasy (cognitive), empathic concern (emotional), and personal distress (emotional). A multivariate analysis revealed significance with divergent thinking (AUT) as the covariate ($F(4, 34) = 3.18$, $p < 0.05$, $h_p^2 = 0.27$). Significance was found in perspective taking ($F(1, 37) = 4.17$, $p < 0.05$, $h_p^2 = 0.10$) and personal distress ($F(1, 37) = 8.55$, $p < 0.01$, $h_p^2 = 0.19$). A multivariate analysis also revealed significance with creative behaviours (BICB) as the covariate ($F(4, 34) = 2.92$, $p < 0.05$, $h_p^2 =$). Significance was found in perspective taking ($F(1, 37) = 11.05$, $p < 0.01$, $h_p^2 = 0.23$) and empathic concern ($F(1, 37) = 4.88$, $p < 0.05$, $h_p^2 = 0.12$). See Figure 2 for scatterplots.


R2 Linear = 0.101
30.00
25.00
20.00
15.00
10.00
5.00
PerspectiveTaking
y=13.69+0.28*x
.00
10.00
20.00
30.00
40.00
DivergentThinking


R2 Linear = 0.188
25.00
20.00
15.00
10.00
5.00
.00
PersonalDistress
y=19.02+-0.39*x
.00
10.00
20.00
30.00
40.00
DivergentThinking



<u>Figure 2:</u> Scatterplot depicting the significant relationships between creativity measures and emotional & cognitive empathy measures

5.4 Discussion

The findings of the current experiment provide support for the assumption that there is a link between creativity and empathy, showing that empathy levels are dependent on an individual's level of creativity: as level of creativity increases level of empathy also increases. However, this finding is not apparent across all creativity and empathy measures within the study. Specifically, an individual's level of creative achievement was not shown to have an effect on any of the measures of empathy. Creative behaviours, on the other hand, was shown to have a significant positive effect on emotional empathy, perspective taking and empathic concern. Furthermore, divergent thinking was shown to have a significant positive effect on perspective taking and personal distress. While these findings are novel, they are in accordance with those of the few previous studies which have investigated the link between creativity and empathy (Carlozzi et al, 1995; Kalliopuska, 1989; Kalliopuska, 1991; Rabinowitch et al, 2013). However, research into this is limited and an in-depth examination into the relationship had not been conducted prior to the present experiment. Moreover, whereas the current study has focused on an adult population, the majority of these previous studies (mentioned above) have used a sample of children.

The only measure of creativity which did not yield any significant results in relation to empathy was creative achievement (CAQ; Carson et al, 2005; Appendix 4). Perhaps this is because the CAQ only considers observable and noteworthy accomplishments, thus aiming to capture Pro-c (expert level creativity) and Big-C creativity (creative genius) (Beghetto & Kaufman, 2007; Kaufman & Beghetto, 2009) which are less characteristic of

the general population. It is anticipated that this measure may yield different results within an expert sample. The present results suggest that the measure of creative behaviours (BICB; Batey, 2007; Appendix 1), which broadly resembles the CAQ in its behavioural approach (Silvia et al, 2012), yet mostly covers little-c creativity (everyday creativity), is a better tool for assessing level of creativity within the general population. Furthermore, the test of divergent thinking (AUT; Guilford et al, 1960; Appendix 6), which is considered to be an estimate or potential predictor of creative problem solving and creative cognition/processing (Piffer, 2012; Runco, 2008), is also a measure little-c creativity.

Findings from the current study provide a deeper insight into the link between creativity and empathy and are supportive of the previous research which has touched upon this. For example, a recent study has investigated the implementation of a musical group interaction (MGI) programme in primary school children (Rabinowitch et al, 2013). The programme, which involved the children performing various musical tasks in the form of pre-arranged musical games, was run for one full school year. Emotional empathy was measured before and after, revealing that MGI children showed higher emotional empathy scores after the study compared to its beginning, and higher scores than the control group of children at the end of the study (Rabinowitch et al, 2013). Similarly, another study investigated a sample of junior ballet dancers (Kalliopuska, 1989). Within this study participants were given four self-esteem questionnaires measuring creativity, empathy and other personality factors. When compared to an age matched control group, the ballet dancers had more interest in other creativity based

behaviours, less interest in technology, and their empathy levels were significantly higher (Kalliopuska, 1989). In addition, a further study conducted by Kalliopuska (1991) yielded similar results, specifically demonstrating that children who studied music obtained higher empathy scores than children who had not studied music.

Other research has hinted at a connection between perspective taking and creativity (Grant & Berry, 2011; Hoever et al, 2012), but none have touched upon fantasy, emotional concern and personal distress in relation to creativity. Thus, these particular findings are imperative in guiding a greater understanding into the creativity-empathy connection. Here, a negative relationship was found in regards to personal distress and divergent thinking, indicating that not all aspects of empathy are positively related to the various types of creativity. While divergent thinking was found to have a negative effect on personal distress, it was also found to have a positive effect on perspective taking, suggesting that the ability to creatively shift one's thoughts in an alternative direction may be a crucial factor in understanding the other person's point of view, as opposed to focusing on how oneself would feel in their situation - thus causing further distress. According to Batson et al (1987), an individual's response to the pain of others may be modulated by both cognitive and motivational processes, which may result in empathic concern, thus instigating altruistic motivation in order to help the other, or personal distress, which may cause egoistic motivation in order to reduce one's own experience of personal distress (Batson et al, 1987). A neuroimaging study conducted by Lamm et al (2007) has provided support of this, showing that when individuals imagine themselves in painful or

dangerous situations, a stronger fearful/aversive response is triggered compared to when they imagine another individual in the same situation. The brain regions which showed stronger activation in the self-perspective condition include the bilateral insular cortices, the anterior midcingulate cortex and the amygdala (all of which are involved in the coding of motivational-affective dimensions of pain), as well as certain structures involved in action control (Lamm et al, 2007).

In conclusion, this study provides empirical evidence suggesting that there is a link between creativity and empathy. It specifically indicates that individuals who are more creative have higher levels of empathy; that is for most types of empathy, personal distress being the exception. This is apparent for both those who engage in a larger number of creative behaviours and for those who have superior creative cognition. The importance of these findings is the implications regarding prosocial behaviour and the encouragement of creativity, whether it be in schools, the prison system (i.e. rehabilitation), and everyday life. These findings could also be considered as a marker for guiding future neuroscientific experiments into the brain regions and neural mechanisms/processes involved in the specific types of creativity and empathy, as so far this remains ambiguous. Future investigations should focus on the effect of creativity in relation to empathy within a sample of experts. The next study follows on from this by looking at the effect of level of creativity on ToM ability (which is considered to be a form of cognitive empathy).

5.5 Chapter Highlights

- Creativity is the ability to produce work that is both novel and appropriate.
- Empathy is the capacity to understand and respond to the unique affective experiences of another person.
- The current experiment examined different types of creativity in relation to the different types of empathy.
- The aims of the current study were to examine whether there was an effect of level of creativity on level of empathy.
- The sample consisted of 39 adult participants.
- Measures included self-reports and tests of cognition.
- Results revealed that individuals who are more creative (specifically those who engage in more creative behaviours and those who have superior creative cognition/divergent thinking) have higher levels of empathy (for most types of empathy).
- The current findings provide some support for the hypothesis and previous research.
- The study has implications for schools and prisons, as well as everyday life.
- Future investigations should focus on the effect of creativity in relation to empathy within a sample of experts.

Chapter 6: Creativity and Theory of Mind

6.1 Introduction

The previous chapter (Chapter 5) has focused on the effects of level of creativity on level of empathy, for different types of creativity and different types of empathy, showing that there is a significant difference in empathy based on creativity, as level of creativity increases, level of empathy also increases (for various types of empathy and creativity). Chapter 5 provides further insight into the connection between creativity and empathy, and this is important because no other research has done an in-depth exploration of the two before. The current study extends that of Chapter 5 by focusing on the effect of level of creativity on ToM ability (as a form of cognitive empathy). This study looks into the same types of creativity as the previous chapter, in relation to two measures of ToM varying in difficulty.

The study of creativity within the domain of psychology had been somewhat neglected, until over the past decade or so when it began to gain a considerable amount of attention (Simonton, 2012). Despite this, there seems to be a gap in the literature investigating creativity in relation to empathy, and more so, theory of mind (ToM) as a form of empathy. The current study intends to bridge that gap by examining whether level of creativity, within a sample of individuals from the general population, as an effect ToM ability. Firstly, the previous research which has examined creativity in relation to empathy (in general) suggests that individuals who are creative, or those who engage in creative behaviours compared to those who do not, score significantly higher on empathy measures and are therefore

more empathetic than non-creative individuals (Carlozzi et al, 1995; Kalliopuska, 1989; Kalliopuska, 1991; Rabinowitch et al, 2013). Other research, focusing specifically on ToM, has provided evidence of a positive correlation between creative cognition and ToM (Suddendorf & Fletcher-Flinn, 1997; Suddendorf & Fletcher-Flinn, 1999).

The definition of creativity is usually thought to involve two criteria (Runco & Jaeger, 2012). These criteria have been termed in various ways, such as ‘novel’ and ‘appropriate’ or ‘original’ and ‘valuable’ etcetera (Mumford & Gustafson, 1988; Sternberg, 1999). Nevertheless, the meaning of such terms within this context remains the same, and thus, creativity has become known to represent an act (or thought) which is in some way unique, as well as being beneficial and fit for purpose. Since this definition is rather generic the ways in which creativity is measured, from a psychological perspective, is also wide ranging. For example, methods of assessment measure a number of different aspects of creativity such as creative cognition, creative behaviour, creative accomplishments, creative products, and creative traits (all from Kaufman et al. 2008).

ToM, otherwise known as mentalizing, is the ability to understand the mental states (including beliefs, hopes desires and intentions) of other individuals, as well as being able to understand one’s own mental states, thus enabling the ability to predict future behaviour based on those mental states (Premack & Woodruff, 1978). The two theories of ToM include: theory-theory, which assumes that ToM is gained by theoretical reasoning (Gallese & Goldman, 1998) and is closely connected to cognitive ToM (Schaafsma et al, 2015), and simulation theory, which assumes that

individuals use their own mentality to imagine other's mental states (Gallese & Goldman, 1998) and is closely connected to emotional ToM (Schaafsma et al, 2015). Theory-theory posits that ToM occurs through learning and experience and simulation theory assumes ToM to be innate and intuitive (Völlm et al, 2006). Brain regions which are thought to be involved in ToM include: the medial prefrontal cortex (mPFC), the superior temporal sulcus (STS), the temporoparietal junction (TPJ), and the temporal poles (TP) (Shamay-Tsoory, 2011).

Here creativity and ToM is examined by employing self-report measures and tests of cognition. Specifically, two tests of cognition examine ToM (ToM Eyes; Appendix 7 and ToM Faces; Appendix 8), both differing in their level of difficulty, and a test of creative cognition is also used to measure divergent thinking. Furthermore, self-reports have been utilised to measure two other aspects of creativity, namely, creative achievement and creative behaviours. It is hypothesised that there will be a significant difference in ToM based on level of creativity as previous research shows a correlation between ToM and divergent thinking (Suddendorf & Fletcher-Flinn, 1997; Suddendorf & Fletcher-Flinn, 1999).

6.2 Method

6.2.1 Participants

The study included 39 male and female adult participants. Exclusion criteria was no history of autism.

6.2.2 Design

The design was a within subjects design as each participant was subjected to the same conditions. A general liner model was utilised to analyse the data, and all measure were standardised.

6.2.3 Materials

6.2.3.1 Self-reports

Biographical Inventory of Creative Behaviours (BICB; Batey, 2007; Appendix 1)

See Chapter 5 for details.

Creative Achievement Questionnaire (CAQ; Carson et al, 2005; Appendix 4)

See Chapter 5 for details.

6.2.3.2 Tests of Cognition

Alternate Uses Test, Form B Test Booklet (AUT; Guilford et al, 1960; Appendix 6)

See Chapter 5 for details.

Faces Test (Baron-Cohen et al, 1997; Appendix 8)

Social cognition is measured through the ToM Faces test which includes 20 images of the full face expressing both basic and complex mental states. The participant was required to choose one out of two words under each image, which they believed was describing the emotion portrayed in each image of the face.

Reading the Mind in the Eyes Test, Revised Version (Baron-Cohen et al, 2001; Appendix 7)

Social cognition is also measured through the ToM Eyes test. This is similar to the ToM Faces test, yet more difficult. The ToM Eyes test was devised in order to create a more sensitive measure of social intelligence within the adult population, which is able to detect meaningful individual differences, unlike the original which is only able to measure extreme performances. This test contains 37 images of the eye region only, expressing different emotional states. With each image there are four words describing various emotions and the participant was instructed to circle the word which they believed described the emotion expressed in each image of the eyes.

6.2.4 Procedure

Experimentation took place at the University of Bradford within an experimental cubicle. Participants firstly provided informed consent, and were then given the Alternate Uses Test, form B test booklet (Guilford et al, 1960; Appendix 6) to complete. The booklet contained two parts; four minutes was permitted per part. Participants then completed the two tests of ToM: the Eyes Test, revised version (Baron-Cohen et al, 2001; Appendix 7) and the Faces Test (Baron-Cohen et al, 1997; Appendix 8). Next to be completed were the creativity questionnaires: the Creative Achievement Questionnaire (Carson et al, 2005; Appendix 4) and the Biographical Inventory of Creative Behaviours (Batey, 2007; Appendix 1). The most challenging tasks were presented to the participants first as they required

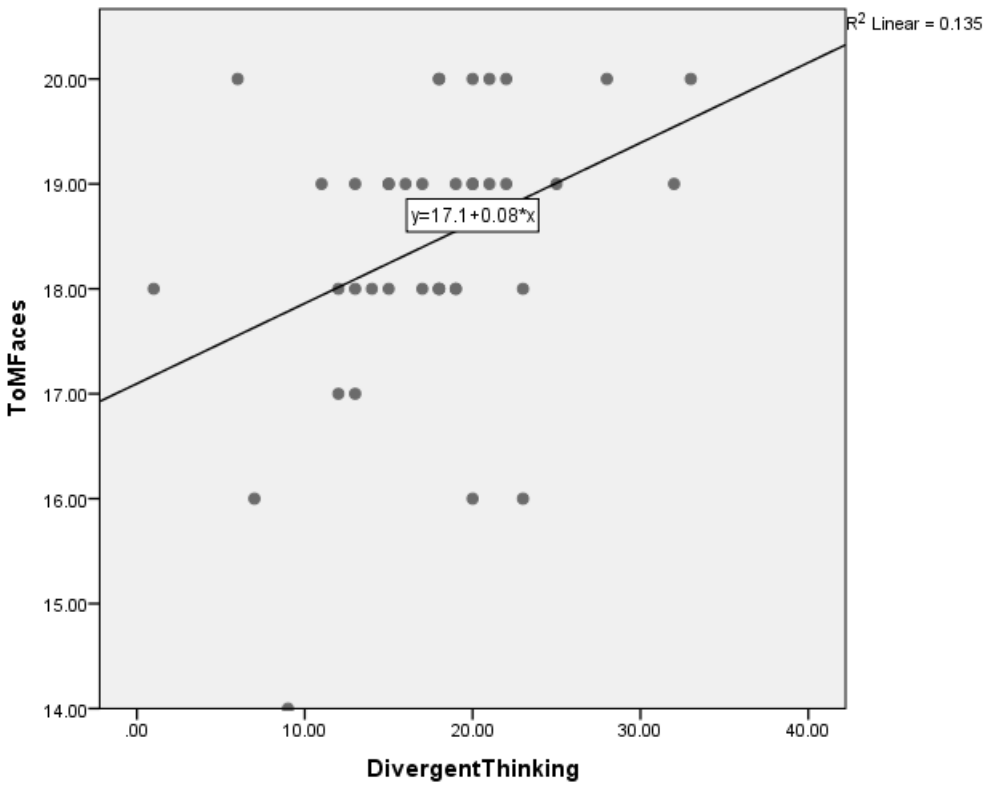
more attention and concentration. Ethical approval was granted from the Chair of the Humanities, Social and Health Sciences Research Ethics Panel, University of Bradford.

6.3 Results

The intention of the present experiment was to investigate whether there is a link between creativity and ToM. Specifically, by examining the effect of level of creativity (for different types of creativity) on level of ToM.

Table 1: Means and Standard Deviations for each Variable

Variable	***Name of Test***	***Mean***	***SD***	***Range (Actual scores)***	***Range (Possible scores)***
Creative Achievement	Creative Achievement Questionnaire (CAQ; Carson et al, 2005)	10.26	8.13	2-36	0->280
Creative Behaviours	Biographical Inventory of Creative Behaviours (BICB; Batey, 2007)	6.77	3.86	1-17	0-34
Divergent Thinking	Alternate Uses Test, Form B Test Booklet (AUT; Guilford et al, 1960)	17.51	6.41	1-33	0-36
ToM Eyes	Reading the Mind in the Eyes Test, Revised Version (Baron-Cohen et al, 2001)	26.67	4.21	17-34	0-37
ToM Faces	Faces Test (Baron-Cohen et al, 1997)	18.44	1.33	14-20	0-20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y=17.1+0.08*x
ToMFaces
DivergentThinking
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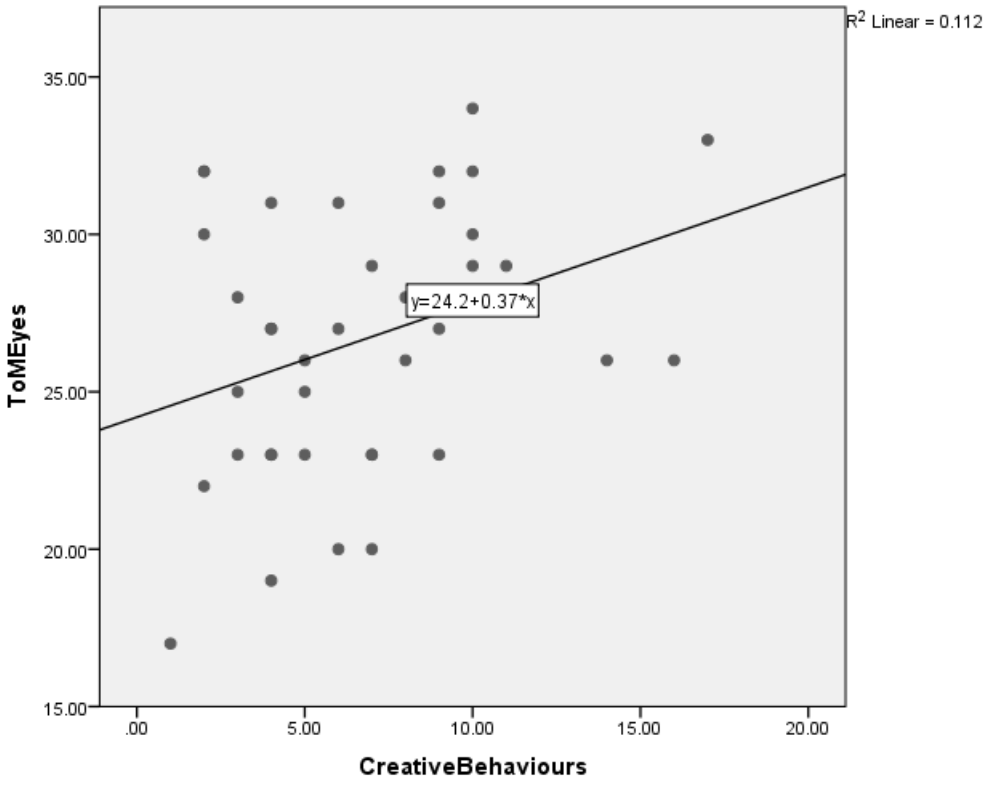
19.00
18.00
17.00
16.00
15.00
14.00
.00
10.00
20.00
30.00
40.00


R² Linear = 0.112
y=24.2+0.37*x
ToMEyes
CreativeBehaviours
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30.00
25.00
20.00
15.00
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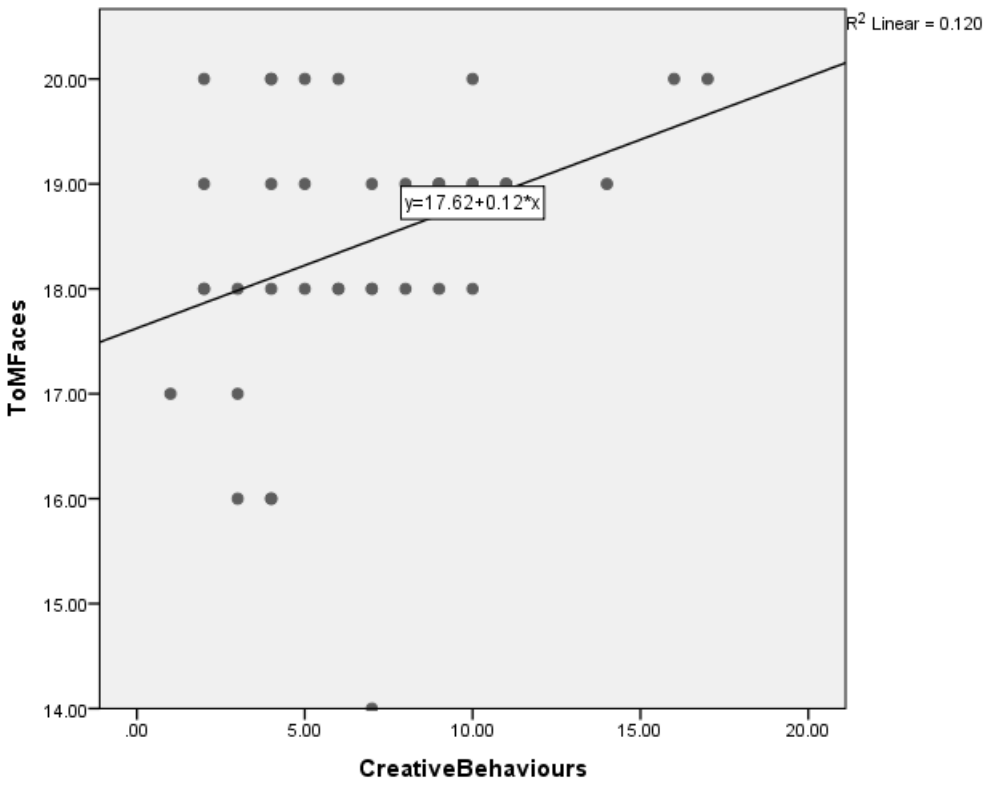
5.00
10.00
15.00
20.00



<u>Figure 3:</u> Scatterplot depicting the significant relationship between creativity measures and ToM measures

Six separate univariate general linear models (GLM) were conducted to test the third hypothesis. In each analysis, the measures of theory of mind were the dependent variable, and the measures of creativity were the covariate. No significant difference was found in any theory of mind test based on creative achievement (N.S), and no statistically significant difference was found in ToM Eyes based on divergent thinking (N.S). However, a significant difference was found in ToM Faces based on divergent thinking scores ($F(1, 37) = 5.77$, $p < 0.05$). Moreover, significant differences were found in ToM Eyes based on creative behaviours ($F(1, 37)$

= 4.68, $p < 0.05$) and ToM Faces based on creative behaviours ($F(1, 37) = 5.07$, $p < 0.05$).

6.4 Discussion

The results of the present experiment reveal a significant difference in ToM Faces based on divergent thinking ability and creative behaviours. Significant differences were also found in ToM Eyes based on creative behaviours. This shows that for these specific findings, as level of creativity increased ToM ability also increased. However, no significant differences were found in ToM based on creative achievement, and no significant difference was found in ToM Eyes based on divergent thinking ability. Thus, the hypothesis, that there will be a significant difference in ToM based on level of creativity, was partly supported.

Perhaps the measure of creative achievement did not generate any significant results, in relation to ToM, because it was the only measure of Pro-c and Big-C creativity within the current study. Both the measure of divergent thinking ability and the measure of creative behaviours, are characteristic of little-c creativity, which is more likely to be a better fit for measuring creativity within the general population. Pro-c creativity refers to expert level creativity and Big-C creativity refers to creative genius, whereas little-c creativity is basically everyday creativity (Beghetto & Kaufman, 2007; Kaufman & Beghetto, 2009).

It seems ambiguous as to whether the current research fits well with previous research on the same subject, as this is greatly lacking. For instance, merely two experiments have investigated creativity and ToM in

relation to one another, with the focus being on divergent thinking as a form of creativity, showing that the two are correlated (Suddendorf & Fletcher-Flinn, 1997; Suddendorf & Fletcher-Flinn, 1999). The first experiment included 40 children (23 girls and 17 boys with a mean age of 50 months) whom completed Wallach and Kogan's (1965) creativity test and a false-belief task (Suddendorf & Fletcher-Flinn, 1997). Findings show a relationship between creativity, specifically the amount and uniqueness of creative responses, and the attribution of false-beliefs (Suddendorf & Fletcher-Flinn, 1997).

The second experiment used a longitudinal and cross-sectional method (Suddendorf & Fletcher-Flinn, 1999). The experiment took two parts, the first involved a sample of 59 preschool children who completed a divergent thinking task, as well as three false-belief tasks. Significantly more items (including original items) were produced by the children who passed the false-belief tasks compared to those who did not. Three months later, 20 children who fail the false-belief tasks within the first part of the experiment took part in the second part. Again, findings revealed that divergent thinking was enhanced in the children who passed the false-belief tasks (Suddendorf & Fletcher-Flinn, 1999).

Other research which has focused on creativity (in the form of creative behaviours) and empathy in general has demonstrated that creativity does have an effect on empathy. In particular, it has been shown that those who either studying or learning to play/perform music, have higher empathy levels than those who have not studied music (Kalliopuska, 1991; Rabinowitch et al, 2013). Similarly, a group of ballet dancers have been shown to have

higher empathy levels than an age matched control group (Kalliopuska, 1989). The ballet dancers also had more interest in other creativity based behaviours and less interest in technology (Kalliopuska, 1989). It should however, be noted that all the studies mentioned above have employed a sample of children as their participants. The current study thus differs as it is the first, as far as we are aware, to utilise an adult sample of participants from the general population to examine the connection between creativity and ToM as a form of empathy.

In conclusion, the current study demonstrates that there is an effect of creativity, specifically little-c creativity in the form of creative behaviours and divergent thinking, on ToM as a form of empathy. The study implies that individuals who are more creative, have a higher ToM ability. These findings do concur with the few previous studies investigating the same connection, however this is largely lacking and has merely focused on child samples. Therefore much more research into creativity and ToM, as well as creativity and empathy in general, is warranted. The present study suggests that creativity should be encouraged due to its positive effect on social cognition. This is particularly important since social cognitive skills such as ToM and empathy guide everyday interactions and are imperative when it comes to co-operation and sociocultural learning. Furthermore, deficits in such skills have been associated with various pathologies, including sociopathy, autism spectrum disorders, and nonverbal learning disorders (Goldstein & Winner, 2012). Future research should focus on gender differences and the effects of creativity within an expert sample. The next chapter examines another naturally varying trait, colour perception, as a predictor of empathy.

6.5 Chapter Highlights

- There seems to be a gap in the literature investigating creativity in relation to empathy, and more so, theory of mind (ToM) as a form of empathy.
- However, some research has provided evidence of a link between creativity and empathy and evidence of a positive correlation between creative cognition and ToM.
- ToM is the ability to understand the mental states of other individuals, and one's own mental states, enabling the ability to predict future behaviour based on those mental states.
- The aims of the current study were to examine whether there was an effect of level of creativity on ToM ability.
- The sample consisted of 39 adult participants with of history of autism.
- Measures included self-reports and tests of cognition.
- Results revealed that there is an effect of creativity, specifically little-c creativity in the form of creative behaviours and divergent thinking, on ToM.
- The current findings provide some support for the hypothesis.
- Much more research into creativity and ToM, as well as creativity and empathy in general, is warranted.
- Future research should focus on gender differences and the effects of creativity within an expert sample.

Chapter 7: Colour Perception and Empathy

This chapter is the subject of a manuscript in preparation entitled 'Colour Perception as a Predictor of Empathy and Theory of Mind', by Kiou J.L. and Lesk V.E

7.1 Introduction

Now that the effects of creativity on empathy (Chapter 5) and ToM (Chapter 6) have been examined, it is important to look into whether colour perception can predict empathy and ToM. The previous chapter (Chapter 6) has focused on the effects of creativity on ToM, for different types of creativity and two measures of ToM varying in difficulty. It was shown that there was a significant positive effect of creativity, specifically little-c creativity in the form of creative behaviours and divergent thinking, on ToM. This finding is important since very little research has focused on the link between creativity and ToM. This chapter focuses on colour perception as a predictor of empathy, a particularly important avenue of research as no other research has examined this before.

Colour perception effects the way in which individuals understand and interact with their surroundings, as colour not only serves as an aesthetic, but also contributes to emotion, cognition and behaviour (Elliot, 2015). However, very little is known about the perceptual capabilities of colour discrimination/acuity in relation to empathy. Nevertheless, the relationship between colour and emotion is clear as much research has focused on this, showing that there are many colour-emotions associations (Clarke & Costall, 2008; Kaya & Epps, 2004; Terwogt & Hoeksma, 1995; Wexner, 1954), and that these may have developed through learning and culture (Choungourian,

1968; Saito, 1996) and/or may simply be a by-product of evolution (Crozier, 1999; Mollon, 1989).

Colour is often used (particularly by artists and designers, and in advertising) to express emotion and elicit an emotional response in others, or to create some kind of atmospheric ambiance (Da Pos & Green-Armytage, 2007). Hence, it is evident that colour can hold a number of different meanings which give the individual extra information about objects and situations (Elliot et al, 2007), and it is these meanings that may cause, influence, or have an impact upon the mood and emotions that are felt when a colour is perceived in a certain context (Dijkstra et al, 2008; Elliot & Niesta, 2008; Kuller et al, 2009; Yildirim et al, 2007). Furthermore, research suggests that not only does the perception of colour affect a person's feelings, but a person's feelings may also affect their perception of colour (Fetterman et al, 2011; Sherman et al, 2012; Ziems & Christman, 1998). Thus, with colour and emotion being so closely connected, it would not be unreasonable to assume that colour perception may be related to empathy.

Colour perception occurs when light is projected onto (or transmitted by) a substance and then detected by the human eye, allowing a small portion of the electromagnetic spectrum to be visible as colour (Fehrman & Fehrman, 2004). The human brain decodes colour in the visual cortex, specifically requiring single-opponent and double-opponent processes in areas V1 and the V4/V8 colour complex (Shapley & Hawken, 2011) (See Chapter 4). Empathy is the capacity to feel and understand the affective experiences of another by sensing their feelings (known as emotional empathy) and/or understanding their perspective (known as cognitive

empathy) (Shamay-Tsoory, 2011) (See Chapter 2). Many brain regions have been shown to be involved in empathy, and emotional empathy and cognitive empathy may comprise of two separate neural systems (Shamay-Tsoory, 2011). Despite this, a functional magnetic resonance imaging (fMRI) based quantitative meta-analysis has identified that specific brain regions are consistently activated during empathy in general; these include the dorsal anterior cingulate cortex, anterior medial cingulate cortex, supplementary motor area (dACC-aMCC-SMA) and the bilateral anterior insula (Fan et al, 2011). However, distinct brain regions were found to be more frequently active during emotional empathy and different distinct brain regions active during cognitive empathy: specifically, the right anterior insula for emotional empathy and the dorsal aMCC for cognitive empathy (Fan et al, 2011). Moreover, the neurochemical mechanism involved in each type of empathy differs; oxytocin is more involved in emotional empathy, whereas dopamine is more involved in cognitive empathy (Shamay-Tsoory, 2011).

The aim of the current research is to determine whether there is a relationship between colour perception (specifically level of colour discrimination ability, also referred to as colour acuity) and empathy. The study firstly explores colour acuity as a predictor of emotional empathy, and also as a predictor of emotional & cognitive empathy in general. The study secondly uses exploratory analysis to examine the four subgroups of the measure of emotional & cognitive empathy. The subgroups are: (i) perspective taking (cognitive), (ii) fantasy (cognitive), (iii) empathetic concern (emotional), and (iv) personal distress (emotional). Since there is a clear link between colour and emotion (Clarke & Costall, 2008; Dijkstra et al, 2008;

Elliot & Niesta, 2008; Kaya & Epps, 2004; Kuller et al, 2009; Terwogt & Hoeksma, 1995; Wexner, 1954; Yildirim et al, 2007), it is hypothesised that colour perception will be a significant predictor of empathy.

7.2 Method

7.2.1 Participants

The sample consisted of 38 adult participants consisting of both males and females. Exclusion criteria was no uncorrectable vision problems, including colour blindness.

7.2.2 Design

All participants underwent the same testing conditions, thus making a within-subjects design. The data were analysed through a regression model. All measures were standardised.

7.2.3 Materials

7.2.3.1 Self-reports

Interpersonal Reactivity Index (IRI; Davis, 1983; Appendix 5)

See Chapter 5 for details.

Toronto Empathy Questionnaire (TEQ; Spreng et al, 2009; Appendix 9)

See Chapter 5 for details.

7.2.3.2 Test of Colour Perception

Farnsworth-Munsell 100 Hue Colour Vision Test (Farnsworth, 1957; Appendix 3)

This method for testing colour perception examines minute differences in colour discrimination on a level which is able to separate individuals with normal colour vision into classes of superior, average and low colour discrimination, whilst also measuring the zones of colour confusion within individuals who exhibit colour defects. A computer based version of the test was employed within the current experiment. The test contains four distinct rows, each consisting of 22 colour blocks varying in hue. The two end blocks of each row serve as an anchor and are immovable. Each participant was required to adjust the blocks between the anchors (row by row) in order to place them in the correct colour hue order, which, if done correctly, would result in the perfect blend from one anchor to the other. The colour hue rows range from i) orange/magenta hues, ii) yellow/green hues, iii) blue/purple and iv) purple/magenta hues, specifically in this order. Participants were given two minutes to complete each row, before scoring the test to obtain their result.

7.2.4 Procedure

The study took place at the University of Bradford within an experimental cubicle, where on arrival, participants gave informed consent. The first task participants completed was the Farnsworth-Munsell 100 Hue Colour Vision Test (Farnsworth, 1957; Appendix 3), followed by empathy measures: the Toronto Empathy Questionnaire (Spreng et al, 2009;

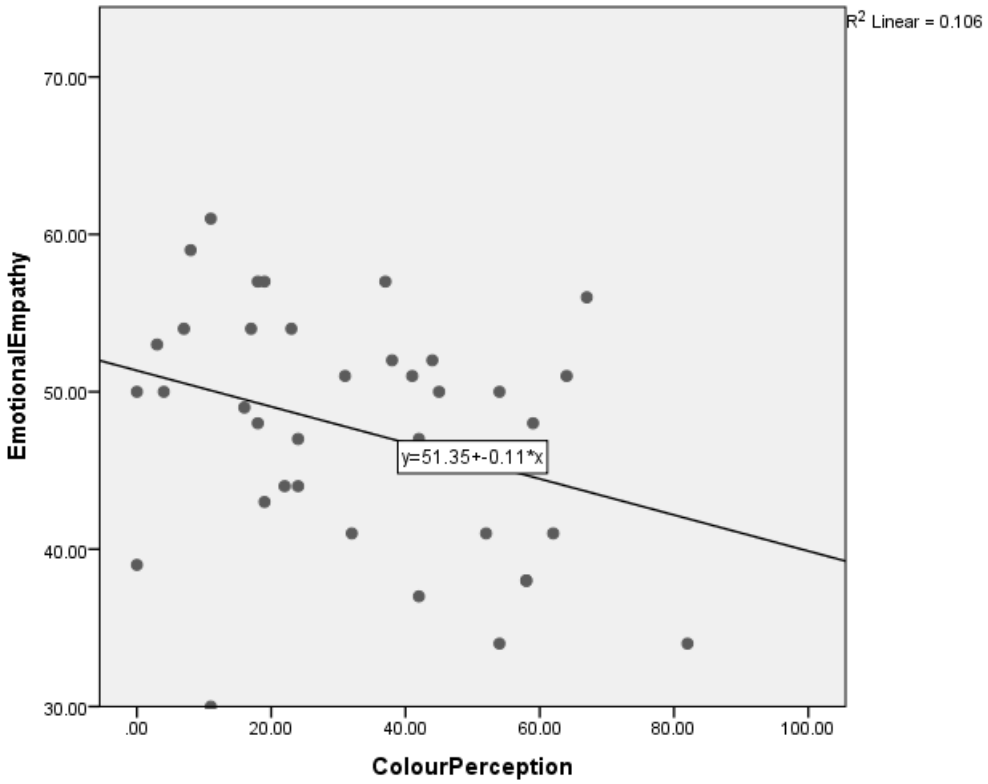
Appendix 9) and the Interpersonal Reactivity Index (Davis, 1983; Appendix 5). Once all the tasks were completed, participants were given the opportunity to ask questions. The tasks requiring the most attention and concentration were presented to the participants first, followed by the questionnaires as these require the least amount of attention and concentration. Ethical approval was granted from the Chair of the Humanities, Social and Health Sciences Research Ethics Panel, University of Bradford.

7.3 Results

The present study aimed to examine colour acuity as a predictor of empathy. See Table 1 for descriptive statistics.

Table 1: Means and Standard Deviations for each Variable

Variable	***Name of Test***	***Mean***	***SD***	***Range (Actual scores)***	***Range (Possible scores)***
Colour Perception	Farnsworth-Munsell 100 Hue Colour Vision Test (Farnsworth, 1957)	32.84	21.50	0-82	0->100
Emotional & Cognitive Empathy	Interpersonal Reactivity Index (IRI; Davis, 1983)	70.50	14.03	35-97	0-112
Emotional Empathy	Toronto Empathy Questionnaire (TEQ; Spreng et al, 2009)	47.50	7.58	30-61	0-64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50.00
40.00
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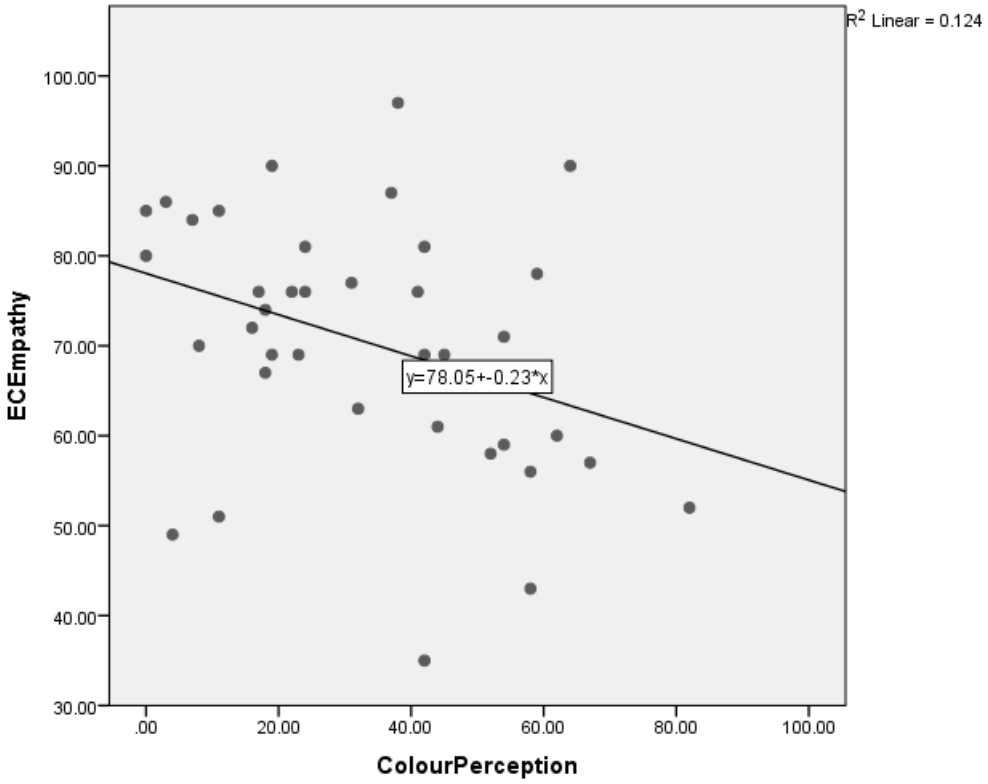
ColourPerception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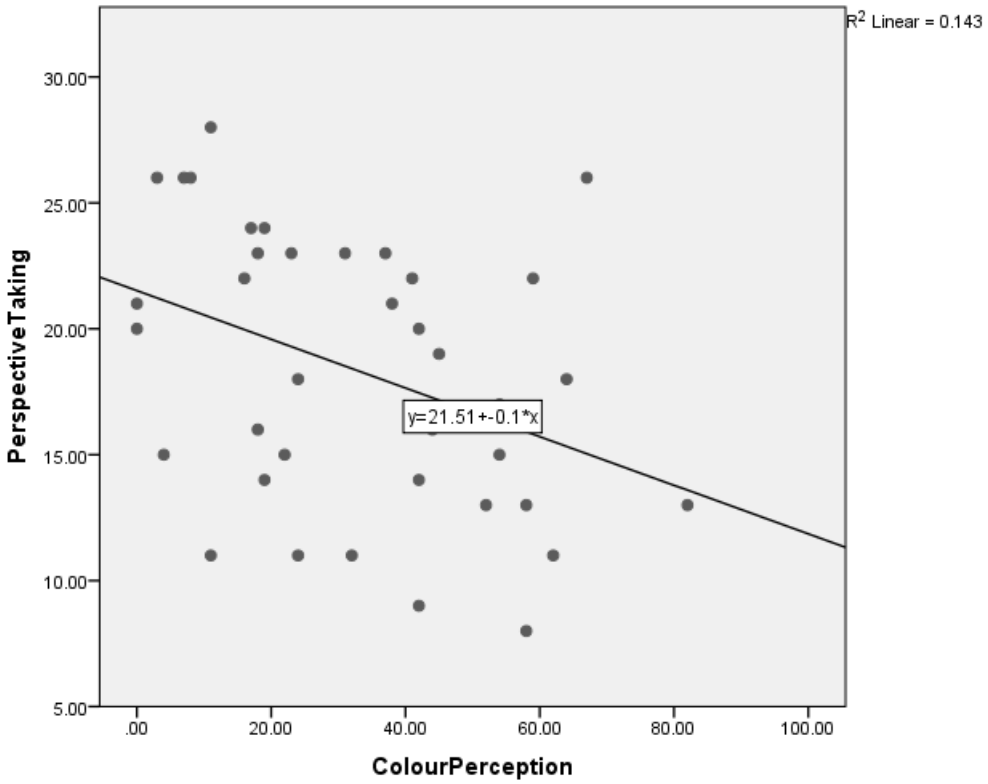
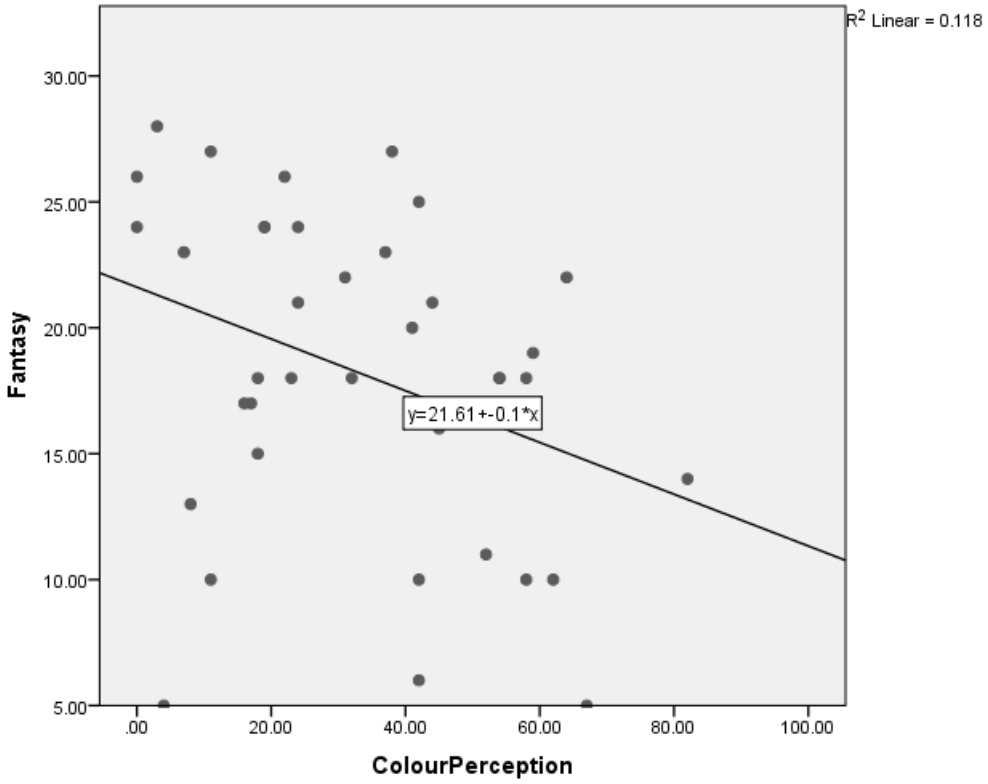
50.00
40.00
30.00
ECEmpathy
y=78.05+-0.23*x
.00
20.00
40.00
60.00
80.00
100.00
ColourPerception

<u>Figure 1:</u> Scatterplots depicting the significant relationships between (1) colour acuity and emotional empathy and (2) colour acuity and emotional & cognitive empathy. A lower colour perception score indicates better/more acute colour perception. It is clear from the two graphs that as colour perception becomes less acute, empathy scores decrease.

Linear regression was conducted to determine whether colour acuity could be a significant predictor of empathy. This was done for emotional empathy and also for emotional & cognitive empathy as a whole. Hence, colour perception was entered into SPSS as the independent variable, with emotional empathy as the dependent variable for the first regression, and emotional & cognitive empathy as the dependent variable for the second regression. The results of the first regression analysis revealed significance ($R^2 = 0.12$, $F(1,36) = 4.26$, $p < 0.05$), whereby colour acuity significantly predicted emotional empathy ($\beta = -0.33$, $t = 2.06$, $p < 0.05$). The results of the second regression also revealed significance ($R^2 = 0.12$, $F(1,36) = 5.10$, $p < 0.05$), whereby colour acuity significantly predicted emotional & cognitive empathy ($\beta = -0.35$, $t = 2.26$, $p < 0.05$). See Figure 1 for scatterplots depicting these results.





<u>Figure 2:</u> Scatterplots depicting the significant relationships between (1) colour acuity and perspective taking and (2) colour acuity and

fantasy (a lower colour perception score indicates better/more acute colour perception)

To investigate the relationship in more detail, exploratory analysis was then used to analyse the subscales of the measure of emotional & cognitive empathy on the IRI. The subscales are: (i) perspective taking (cognitive empathy), (ii) fantasy (cognitive empathy), (iii) empathic concern (emotional empathy), and (iv) personal distress (emotional empathy). These subscales were entered into a multivariate general linear model as dependent variables and colour perception was entered as the covariate. Neither of the emotional empathy subscales were found to be significant (N.S), however, significance was found for both of the cognitive empathy subscales; namely, perspective taking ($F(1, 36) = 5.99$, $p < 0.05$) and fantasy ($F(1, 36) = 4.82$, $p < 0.05$). See Figure 2.

7.4 Discussion

This is the first study to examine colour perception in relation to empathy. The findings support the initial hypothesis in showing colour acuity to be a predictor of empathy. This was found for emotional empathy and also for emotional & cognitive empathy taken as a whole. Since the measure of emotional & cognitive empathy is comprised of four subscales (empathic concern and personal distress for emotional empathy, and perspective taking and fantasy for cognitive empathy), further exploratory analysis was undertaken. This revealed a significant effect of colour acuity on each of the cognitive empathy subscales (those with more acute colour perception had

higher levels of cognitive empathy), but no significant effect of colour acuity on either of the emotional empathy subscales.

The premise of the current study, investigating whether there is a link between colour perception and empathy, comes from the extensive and widely acknowledged relationship between colour and emotion (Clarke & Costall, 2008; Dijkstra et al, 2008; Elliot & Niesta, 2008; Kaya & Epps, 2004; Kuller et al, 2009; Terwogt & Hoeksma, 1995; Wexner, 1954; Yildirim et al, 2007). The most similar research to that of the current study comes from research examining colour perception in relation to emotion, particularly focusing on the effect of emotion in influencing colour perception (Fetterman et al, 2011; Sherman et al, 2012; Ziems & Christman, 1998). For example, it has been shown that priming concepts of anger (versus sadness) led participants to be more likely to perceive red (a colour commonly associated with anger) as opposed to blue in ambiguous colour stimuli, and the same was also found for 'evoked' anger (Fetterman et al, 2011). Another study has focused on the emotion of disgust and the colour white (due to its association with purity) in a series of three experiments (Sherman et al, 2012). Within this study, participants who reported greater sensitivity towards disgusting stimuli demonstrated greater ability at making subtle grayscale discriminations. Furthermore, disgust-sensitive individuals exhibited a heightened ability at detecting deviations from white after viewing disgusting images (Sherman et al, 2012). Thus, such findings concur with the current research as they suggest that emotion and emotional sensitivity is related to colour and colour perceptual sensitivity.

Interestingly, the current findings show colour acuity to be a significant predictor of emotional empathy, measured by the TEQ (Spreng et al, 2009; Appendix 9). However, when the subscales of the IRI (Davis, 1983; Appendix 5) were analysed, colour acuity was not shown to have a significant effect on either of the two emotional empathy subscales (empathetic concern and personal distress), yet a significant effect was found for each of the cognitive empathy subscales (perspective taking and fantasy), and colour acuity was shown to be a significant predictor of the measure as a whole. Both the TEQ and IRI have previously been shown to demonstrate good reliability and validity (Christopher et al, 1993; Davis & Franzoi, 1991; Spreng et al, 2009). Thus, these findings add to the ambiguity concerning empathy and the extent to which emotional and cognitive empathy are distinct versus similar.

Dopamine may be a relevant factor to consider in relation to the current research findings, as dopamine levels are implicated in both colour perception and empathy. In particular, much research suggests that impaired colour perception, specifically on the blue-yellow axis, is related to retinal dopaminergic deficiencies (Banaschewski et al, 2006; Colzato et al, 2014; Hulka et al, 2013; Tannock et al., 2006). One recent study conducted by Colzato et al (2014), has shown individual differences in colour discrimination (considered as a marker of dopamine functioning) to statistically predict differences in the strength and stability of cognitive control within a sample of healthy young adults. Better colour discrimination led to more efficiency in resolving response conflict, and a blue-yellow colour vision impairment was associated with less efficiency in handling response conflict

(Colzato et al, 2014). Research also suggests that cognitive empathy is associated with dopaminergic functioning (Lackner et al, 2010; Uzefovsky et al, 2014). Hence, the link between dopamine and colour perception, and dopamine and cognitive empathy, may explain the findings of the exploratory analysis of the IRI subscales (showing colour acuity to have a significant effect on cognitive empathy but not emotional empathy).

In conclusion, the present experiment is the first to provide evidence of an association between colour perception and empathy. Specifically showing colour acuity to be a significant predictor of empathy. As a result, more research is needed into investigating the relationship between colour perception and empathy in order to establish the extent to which colour acuity is an important factor in relation to the different types of empathy, and also whether this is dependent on the main colour confusion axis. If the observed effect concerns the blue-yellow axis only, and is related to cognitive empathy, it may suggest that dopamine is involved. This now needs to be examined with different groups of people to test the effects of age and gender. This study also has implications for better understanding disorders such as autism, ADHD, schizophrenia, addictive behaviours and Parkinson's disease, all of which have been linked to dopamine. The next study extends this one by looking at colour perception in relation to ToM.

7.5 Chapter Highlights

- Very little is known about the perceptual capabilities of colour discrimination/acuity in relation to empathy.

- The relationship between colour and emotion is clear, as much research has focused on this, showing that there are many colour-emotions associations.
- Research suggests that a person's feelings may also affect their perception of colour.
- The aims of the current study were to examine whether colour perception is a predictor of empathy.
- The sample consisted of 38 adult participants.
- Measures included self-reports and a measure of colour perception.
- Results revealed colour perception to be a predictor of emotional empathy and emotional & cognitive empathy taken as a whole.
- The current findings provide support for the hypothesis.
- Dopamine may be a relevant factor to consider in relation to the current research findings, as dopamine levels are implicated in both colour perception and empathy.
- More research is needed into investigating the relationship between colour perception and empathy in order to establish the extent to which colour acuity is an important factor in relation to the different types of empathy, and also whether this is dependent on the main colour confusion axis.
- This study has implications for better understanding disorders such as autism, ADHD, schizophrenia, addictive behaviours and Parkinson's disease, all of which have been linked to dopamine.

Chapter 8: Colour Perception and Theory of Mind

This chapter is the subject of a manuscript in preparation entitled 'Colour Perception as a Predictor of Empathy and Theory of Mind', by Kiou J.L. and Lesk V.E

8.1 Introduction

The previous chapter (Chapter 7) has looked into colour perception as a predictor of empathy (for different types of empathy). It was shown that colour perception is a predictor of emotional empathy and emotional & cognitive empathy taken as a whole. However, exploratory analysis into the subscales of the emotional & cognitive empathy measure revealed a significant effect of colour acuity/perception on each of the cognitive empathy subscales (higher cognitive empathy levels was found for those with more acute colour perception), but no significant effect of colour acuity/perception on either of the emotional empathy subscales. Thus, adding to the ambiguity concerning empathy and the extent to which emotional and cognitive empathy are distinct versus similar. The current study extends that of Chapter 7 by focusing on colour perception as a predictor of ToM (a form of cognitive empathy). This study utilises the same measures of colour perception and ToM as the previous chapters.

Whether or not consciously recognised, the subtle stimulation of seeing colour affects our everyday lives (Jalil et al, 2012); and it is evident that the perception of colour has many useful applications to humans, influencing factors such as emotion, cognition and behaviour (Elliot, 2015). Various research has looked into the effects of emotion in influencing colour perception (Barrick et al, 2002; Fetterman et al, 2011; Sherman et al, 2012;

Ziems & Christman, 1998), however, the question remains as to whether or not there is a link between colour perception and theory of mind (ToM), both of which vary within the general population.

For humans, only a small portion of the electromagnetic spectrum is visible to the eye; this is known as colour and is perceived when light is projected onto (or transmitted through) a substance (Fehrman & Fehrman, 2004). Colour processing is complex and involves a number of stages, beginning with cone photoreceptors absorbing light (Conway, 2009). Retinal signals carry colour information which is transmitted through the lateral geniculate nucleus of the thalamus (LGN) and up to the primary visual cortex (V1) (Conway, 2009). These signals are then processed by the second visual area (V2), followed by cells located in sub-compartments (labelled as 'globs') within the posterior inferior temporal (PIT) cortex (the brain region encompassing area V4 and areas immediately anterior to V4). Further colour processing occurs within the inferior temporal (IT) cortex including area TE (Conway, 2009).

Theory of mind (ToM) can be defined as the ability to acknowledge the mental states of oneself and of others in order to predict behaviour based on those specific mental states (Premack & Woodruff, 1978). This ability to imagine another person's thoughts and feelings is considered to be a form of cognitive empathy, and is also commonly referred to as mentalizing (Shamay-Tsoory, 2011). The set of brain regions implicated in ToM include: the medial prefrontal cortex (mPFC), the superior temporal sulcus (STS), the temporoparietal junction (TPJ), and the temporal poles (TP) (Shamay-Tsoory, 2011).

There may be a connection between colour perception and ToM through the neurotransmitter dopamine (DA). It is, however, difficult to directly assess DA function in humans, as this is only possible via positron emission tomography (PET), which is both expensive and invasive due to radioactive contamination and arterial blood sampling (Colzato et al, 2014). Thus, where some studies show a direct link to DA, others merely suggest that a link may exist. Firstly, the link between DA and cognitive empathy has been demonstrated in a recent two-part study conducted by Uzefovsky et al (2014). The studies examined the association between the dopamine D4 receptor (DRD4) and empathy, whilst also investigating the effect of gender. Study 1 consisted of 477 adult participants who completed empathy inventories (for cognitive empathy and emotional empathy) and were genotyped for the DRD4 exon 3 polymorphism (Uzefovsky et al, 2014). DRD4 is a gene which encodes the D4 receptor of dopamine and has a number of variations known as polymorphisms (Ben-Israel et al, 2015). The 7-repeat allele (7R-allele), within the exon 3 polymorphism, is one of the most researched because of its relevance to individual differences in social behaviour (Ben-Israel et al, 2015). Findings revealed that women scored higher on all empathy measures than men (Uzefovsky et al, 2014). No main effect of genotype was observed, however, a significant interaction was found between genotype and gender for cognitive empathy (but not emotional empathy). Specifically, women carriers of the 7R-allele scored higher than non-carriers, whereas men 7R-allele carriers scored lower than non-carriers.

Study 2 consisted of 121 participants from an independently recruited sample and findings replicate those of Study 1. Overall, the findings show the DRD4 exon 3 polymorphism to be associated with cognitive empathy, and the direction of the association to be gender-sensitive (Uzefovsky et al, 2014). Another study examined a sample of 91 children aged between 48–62 months and found average eye blinks per minute (EBR) to be a strong unique predictor of children's representational theory of mind (RTM) performance, thus providing indirect support for DA as being an important neurodevelopmental factor which affects RTM development (Lackner et al, 2010). Secondly, various research suggests that DA is linked to colour perception, specifically indicating poor discrimination on the blue-yellow axis due to a hypo-dopaminergic state in the retina (Banaschewski et al, 2006; Colzato et al, 2014; Hulka et al, 2013; Tannock et al., 2006).

This research aims to determine whether colour perception is related to ToM (a form of cognitive empathy). Colour perception is examined through measuring individuals' level of colour discrimination ability (referred to here as 'colour acuity') via the Farnsworth-Munsell 100 Hue Colour Vision Test (Farnsworth, 1957). Two measures of ToM have been employed due to their varying level of complexity; ToM Eyes is a more complex measure than ToM Faces. Colour perception is hypothesised to be a significant predictor of ToM as DA seems to be implicated in both, and there is also a well-documented link between colour and emotion.

8.2 Method

8.2.1 Participants

The participants consisted of 38 individuals, both male and female. All participants were 18 and over. Exclusion criteria included no history of autism and no uncorrectable vision problems, including colour blindness.

8.2.2 Design

A within subjects design was used where each participant experienced the same testing conditions. The data were analysed through a regression model, and all measures were standardised.

8.2.3 Materials

8.2.3.1 Tests of Cognition

Faces Test (Baron-Cohen et al, 1997; Appendix 8)

See Chapter 6 for details.

Reading the Mind in the Eyes Test, Revised Version (Baron-Cohen et al, 2001; Appendix 7)

See Chapter 6 for details.

8.2.3.2 Test of Colour Perception

Farnsworth-Munsell 100 Hue Colour Vision Test (Farnsworth, 1957; Appendix 3)

See Chapter 7 for details.

8.2.4 Procedure

The experiment was conducted at the University of Bradford within an experimental cubicle. Participants provided informed consent before completing the Farnsworth-Munsell 100 Hue Colour Vision Test (Farnsworth, 1957; Appendix 3). They then completed the two ToM tests: the Eyes Test, revised version (Baron-Cohen et al, 2001; Appendix 7) and the Faces Test (Baron-Cohen et al, 1997; Appendix 8). More challenging tasks were presented to the participants first. Ethical approval was granted from the Chair of the Humanities, Social and Health Sciences Research Ethics Panel, University of Bradford.

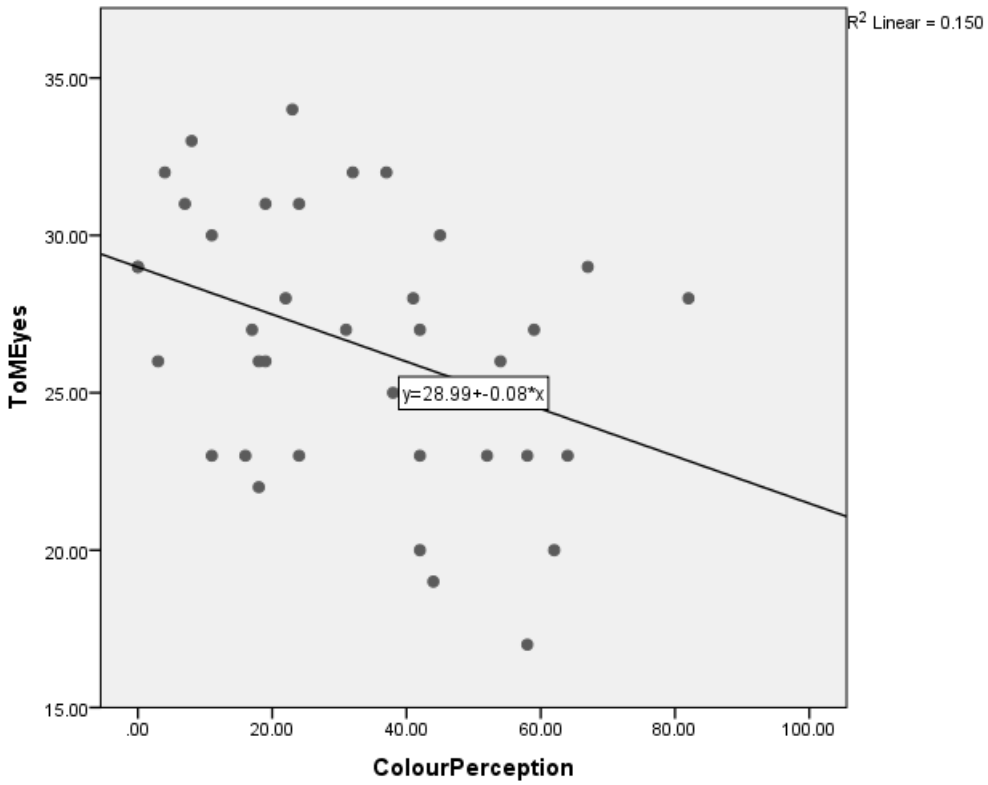
8.3 Results

The present study aimed to examine colour acuity as a predictor of ToM. See Table 1 for descriptive statistics.

Table 1: Means and Standard Deviations for each Variable

Variable	***Name of Test***	***Mean***	***SD***	***Range (Actual scores)***	***Range (Possible scores)***
Colour Perception	Farnsworth-Munsell 100 Hue Colour Vision Test (Farnsworth, 1957)	32.84	21.50	0-82	0->100
ToM Faces	Faces Test (Baron-Cohen et al, 1997)	18.57	1.24	14-20	0-20
ToM Eyes	Reading the Mind in the Eyes Test, Revised Version (Baron-Cohen et al, 2001)	26.67	4.28	17-34	0-37

Linear regression was conducted to determine whether colour acuity is a significant predictor of ToM. This was done for ToM Faces and for ToM Eyes. Colour perception was entered into SPSS as the independent variable, with ToM Faces as the dependent variable for the first regression, and ToM Eyes as the dependent variable for the second regression. The results of the first regression analysis revealed non-significance (N.S). The results of the second regression did reveal significance ($R^2 = 0.15$, $F(1,36) = 6.34$, $p < 0.05$), indicating that colour acuity significantly predicted ToM Eyes ($\beta = -0.39$, $t = 2.52$, $p < 0.05$). See Figure 1.



<u>Figure 1:</u> Scatterplot depicting the significant relationship between colour perception and ToM Eyes (a lower colour perception score indicates better/more acute colour perception)

8.4 Discussion

The results of the present experiment show colour acuity to be a significant predictor of ToM for the Eyes Test (Baron-Cohen et al, 2001; Appendix 7), but not the Faces test (Baron-Cohen et al, 1997; Appendix 8), thus providing some support for the hypothesis that colour perception will be a significant predictor of ToM. As expected, although the Faces Test did not reach significance, both measures did demonstrate a positive relationship to colour acuity, indicating that better colour perception is related to better ToM ability within the general population. Perhaps significance was obtained for the Eyes Test, but not the Faces Test, because the Eyes Test was devised in order to generate a more sensitive measure of adult social intelligence that can detect meaningful individual differences, whereas the original (Faces Test) was merely designed as a measure of extreme performances (Baron-Cohen et al, 2001).

So far, research seems to suggest that emotion influences colour perception, with the focus being on negative emotions. For example, some research suggests that depression impairs colour perception/sensitivity (Barrick et al, 2002), whereas other research implies that certain negative emotions enhance colour discrimination for the colours associated to that particular emotion (i.e. red for anger; white/grey for disgust) (Fetterman et al, 2011; Sherman et al, 2012). The current study differs, and thus, is novel in the sense that it demonstrates that an individual's level of colour perception (in the form of colour discrimination) is positively related to, and can predict, their social and emotional cognition (in the form of ToM).

Other than a well-documented link between colour and emotion (as delineated above), another conceivable connection which could explain the current findings, is the mutual implication of the neurotransmitter DA in (i) colour perception (Banaschewski et al, 2006; Colzato et al, 2014; Hulka et al, 2013; Tannock et al., 2006) and (ii) cognitive empathy (Lackner et al, 2010; Uzefovsky et al, 2014). The research findings relating DA to colour perception suggest that the link specifically pertains to the blue-yellow colour axis, and is due to dopaminergic deficiencies in the retina. However, this is beyond the scope of the current study as this experiment centred on the full spectrum and did not discriminate between certain colour axes. For this reason, further research into different colour axes in relation to ToM (and empathy in general) is warranted.

The current findings are also in line with autism research. It is apparent that autistic individuals have an impaired ToM, and thus, exhibit difficulty in understanding the complex mental states of others' goals and intentions (Baron-Cohen et al, 1985; Leslie & Thaiss, 1992; Sodian & Frith, 1992). Furthermore, it has also been demonstrated that individuals with autism perform less well (than controls) in colour discrimination tasks, and thus display impaired colour perception (Cranwell et al, 2015; Franklin et al, 2008; Franklin et al, 2010; Hurlbert et al, 2011). Hence, such research clearly suggests that a link between colour perception and ToM does exist, specifically indicating that they are both positively related, and that performance in colour perception can significantly predict performance in ToM (as demonstrated in the present experiment).

The present experiment is the first to show an association between colour perception and ToM. A positive relationship between the two has been demonstrated, and moreover, colour acuity was found to be a significant predictor of ToM in the Eyes Test, but not the Faces Test. Further research into this would be beneficial in assessing whether the same can be found in other measures of ToM and various other measures of cognitive empathy in general. Furthermore, research could take a deeper look into this relationship by distinguishing between the different colour axes, and whether or not DA is an important factor in explaining the observed results. Obtaining a greater understanding of the relationship between colour perception and social cognition may contribute to further understanding of the neural mechanisms involved in various social cognitive deficits such as those found in autism. The next study follows on from this by examining sensory processing sensitivity (an embodied trait) in relation to empathy, ToM and colour perception.

8.5 Chapter Highlights

- Various research has looked into the effects of emotion in influencing colour perception.
- The question remains as to whether or not there is a link between colour perception and ToM.
- There may be a connection between colour perception and ToM through the neurotransmitter dopamine (DA).
- The aims of the current study were to examine whether colour perception is a predictor of ToM.

- The sample consisted of 38 adult participants with no history of autism and no uncorrectable vision problems, including colour blindness.
- Measures included tests of cognition and a measure of colour perception.
- Results revealed colour perception to be a predictor of ToM Eyes, but not ToM Faces, thus providing some support for the hypothesis.
- The current findings are also in line with autism research as autistic individuals have an impaired ToM and perform less well (than controls) in colour discrimination tasks, and thus display impaired colour perception.
- The present experiment is the first to show an association between colour perception and ToM, therefore further research is warranted.
- Obtaining a greater understanding of the relationship between colour perception and social cognition may contribute to further understanding of the neural mechanisms involved in various social cognitive deficits such as those found in autism.

Chapter 9: Sensory Processing Sensitivity, Empathy, Theory of Mind, and Colour perception

This chapter is the subject of a manuscript in preparation entitled 'The Link between Sensory Processing Sensitivity, Empathy, Theory of Mind, and Colour Perception', by Kiou J.L. and Lesk V.E

9.1 Introduction

The previous chapter (Chapter 8) focused on colour perception as a predictor of ToM. It was found that colour perception was a significant predictor of ToM Eyes, but not ToM Faces, thus providing some support for the hypothesis. It was the first experiment to show an association between colour perception and ToM, therefore much more research into this is needed. The current study looks into sensory processing sensitivity (SPS) in relation to empathy, ToM and colour perception. SPS is related to embodiment as it is concerned with sensing, and is important to study in relation to empathy/ToM and colour perception as little research has focused on this. Furthermore, it is important to discover some of the positive aspects related to SPS, which may benefit those who are highly sensitive individuals, as much of the research tends to focus on its negative aspects.

Sensory processing sensitivity (SPS) refers to the extent to which an individual is sensitive, or responsive, to their surroundings, including both environmental (weather, smells, noises) and social (crowded spaces, conflict amongst others, others' moods) stimuli (Acevedo et al, 2014). Individuals high in SPS, measured by the Highly Sensitive Persons Scale (HSPS) (Aron & Aron, 1997; Appendix 10), are able to detect subtle differences within the

environment, such as changes in temperature, as they process and respond to lower thresholds of information (Liss et al, 2005). According to Aron and Aron (1997), the highly sensitive person (HSP) has a more sensitive nervous system (where the nerves are overly reactive), and is thus, more easily overwhelmed when exposed to highly stimulating environments. This condition occurs in approximately 15-20 percent of the population (Aron, 1999). The HSPS comprises of three subscales of forms of sensitivity, these are: (i) Ease of Excitation, (ii) Aesthetic Sensitivity, and (iii) Low Sensory Threshold (Smolewska et al, 2006). A high score in ease of excitation is related to being mentally overwhelmed by both internal (pain, hunger, taste) and external (light, noise) stimuli. Individuals who score high in aesthetic sensitivity have greater awareness and appreciation of beauty, and those who score high in low sensory threshold are more likely to feel unpleasantly aroused by external stimuli such as bright lights and loud noises (Smolewska et al, 2006). Given the previous results of experiments within this thesis, for example, showing colour perception to be a predictor of empathy (Chapter 7) and ToM (Chapter 8), it now seems important to investigate this in relation to SPS in order to determine whether being sensitive in general (or whether certain types of sensitivities) affects social cognition, and if so, whether colour perception affects SPS, as there is a lack of research into this.

The HSPS (Appendix 10) is a valid and reliable measure of the construct of SPS (Smolewska et al, 2006). It is important to look into the positive aspects of SPS as the current research does, since much research has tended to focus on its negative aspects, including stress and ill health (Benham, 2006), anxiety (Liss et al, 2005; Neal et al, 2002), depression (Liss

et al, 2005), social phobia (Neal et al, 2002), avoidant personality disorder (Meyer & Carver, 2000), and social introversion and emotionality (Aron & Aron, 1997). Furthermore, while high SPS itself is not a disorder, sensory processing disorder (where individuals may be over-responsive or under-responsive to sensory input/stimulation) has been linked to autism, as those with autism have been shown to have abnormal auditory, visual, touch, and oral sensory processing compared to controls (Kern et al, 2006). However, research into the HSPS subscales has shown aesthetic sensitivity to be related to more positive and beneficial outcomes such as well-being, positive affect and openness to experience (Sobocko & Zelenski, 2015), as well as conscientiousness (Ahadi & Basharpoor, 2010), greater attention to detail and good communication (Liss et al, 2008).

Empathy refers to the ability to sense the feelings of others (emotional empathy) and the ability to understand the perspective of others (cognitive empathy) (Shamay-Tsoory, 2011). Theory of mind (ToM) is a form of cognitive empathy which refers to the ability to acknowledge mental states of the self and of others in order to predict behaviour based on those specific mental states, including beliefs, hopes, desires and intentions (Premack & Woodruff, 1978), as introduced in Chapter 2. Colour perception (also referred to here as colour acuity), which occurs when light is transmitted through a substance becoming visible to the human eye, has already be found to be a predictor of empathy and ToM (Chapters 7 and 8). This is the first experiment to be investigating colour perception in relation to SPS.

Although research into SPS and empathy is sparse, one particular study conducted by Acevedo et al (2014) has found a link between the two.

The fMRI study investigated SPS in relation to the perception of other people's emotions. During the first part of the experiment, 18 participants viewed photos of either their romantic partners or of strangers displaying positive (happy) or negative (sad) facial expressions. The experiment was replicated a year later with 13 of the 18 participants with an added neutral facial expression condition. Brain activations were found in regions concerned with awareness, integration of sensory information, empathy (including a region of the mirror neuron system – the inferior frontal gyrus), and action planning in individuals scoring higher in SPS. Furthermore, stronger activations were found in response to the images of individuals displaying positive emotions, and for the images of the participants' romantic partners. The findings suggest that highly sensitive individuals have greater awareness and are more in tune with environmental stimuli as they show stronger activations within brain areas concerned with awareness and integration of sensory information, and are more receptive to other people's needs and emotions due to the enhanced activation in empathy brain regions. Moreover, this is enhanced for positive emotions and for individuals whom the participants care for (Acevedo et al, 2014). Furthermore, other research suggests that individuals high in SPS exhibit greater emotional responses to both positive and negative images (Jagiellowicz et al, 2016).

The current research firstly aims to examine whether there is an effect of SPS on level of empathy (including emotional and cognitive empathy: IRI – Appendix 5, and emotional empathy: TEQ – Appendix 9) and ToM. Exploratory analysis also examines the subscales of the emotional and cognitive empathy measure, which include: (i) perspective taking (cognitive),

(ii) fantasy (cognitive), (iii) empathetic concern (emotional), and (iv) personal distress (emotional). Secondly, the research aims to examine whether there is an effect of colour acuity on SPS as this has been found to be a predictor of empathy and ToM in previous experiments (Chapters 7 and 8), and exploratory analysis examines the subscales of the HSPS (including ease of excitation, aesthetic sensitivity, and low sensory threshold). As individuals high in SPS have been shown to have greater emotional and empathetic responses to both positive and negative stimuli (Acevedo et al, 2014; Jagiellowicz, 2016), it is hypothesised that those high in SPS will score significantly higher on empathy and ToM measures, especially since both SPS and empathy are characterized by feeling and responding more greatly to external stimuli. Moreover, since SPS is characterised by greater responsiveness to environmental stimuli (Liss et al, 2005), it is also hypothesised that individuals with more acute colour perception will score higher in SPS.

9.2 Method

9.2.1 Participants

The sample consisted of 42 adult participants ranging from 18 years of age to 70 years of age, with a mean age of 30.12. A total of 14 males and 28 females took part. Exclusion criteria was no history of autism and uncorrectable vision problems, including colour blindness.

9.2.2 Design

The design was a within-subjects design as each participant underwent the same conditions. All measures were standardised and the data was analysed through a general linear model and a regression model.

9.2.3 Materials

9.2.3.1 Self-reports

Highly Sensitive Person Scale (HSPS; Aron & Aron, 1997; Appendix 10)

The HSPS is a measure of SPS. It utilises a seven point Likert scale ranging from 'Not at All' to 'Extremely', with 'Moderately' in the middle, and consists of 27 statements. The participant must write, next to each statement, the number which describes the extent to which the statement applies to them. The measure contains three subscales: Ease of Excitation (the extent to which someone is mentally overwhelmed by both internal (pain, hunger, taste) and external (light, noise) stimuli), Aesthetic Sensitivity (an individual's level of awareness and appreciation of beauty), and Low Sensory Threshold (the extent to which someone feels unpleasantly aroused by external stimuli such as bright lights and loud noises).

Interpersonal Reactivity Index (IRI; Davis, 1983; Appendix 5)

See Chapter 5 for details.

Toronto Empathy Questionnaire (TEQ; Spreng et al, 2009; Appendix 9)

See Chapter 5 for details.

9.2.3.2 Tests of Cognition and Perception

Farnsworth-Munsell 100 Hue Colour Vision Test (Farnsworth, 1957; Appendix 3)

See Chapter 7 for details.

Reading the Mind in the Eyes Test, Revised Version (Baron-Cohen et al, 2001; Appendix 7)

See Chapter 6 for details.

9.2.4 Procedure

The experiment was an anonymous online study. Firstly, participants provided informed consent and then completed the Farnsworth-Munsell 100 Hue Colour Vision Test (Farnsworth, 1957; Appendix 3). This was followed by the Highly Sensitive Person Scale (HSPS; Aron & Aron, 1997; Appendix 10) and the ToM Eyes Test, revised version (Baron-Cohen et al, 2001; Appendix 7). The participants then filled in the empathy questionnaires, which included the Toronto Empathy Questionnaire (TEQ; Spreng et al, 2009; Appendix 9) and the Interpersonal Reactivity Index (IRI; Davis, 1983; Appendix 5) respectively. More challenging tasks were presented first. Ethical approval was granted from the Chair of the Humanities, Social and Health Sciences Research Ethics Panel, University of Bradford.

9.3 Results

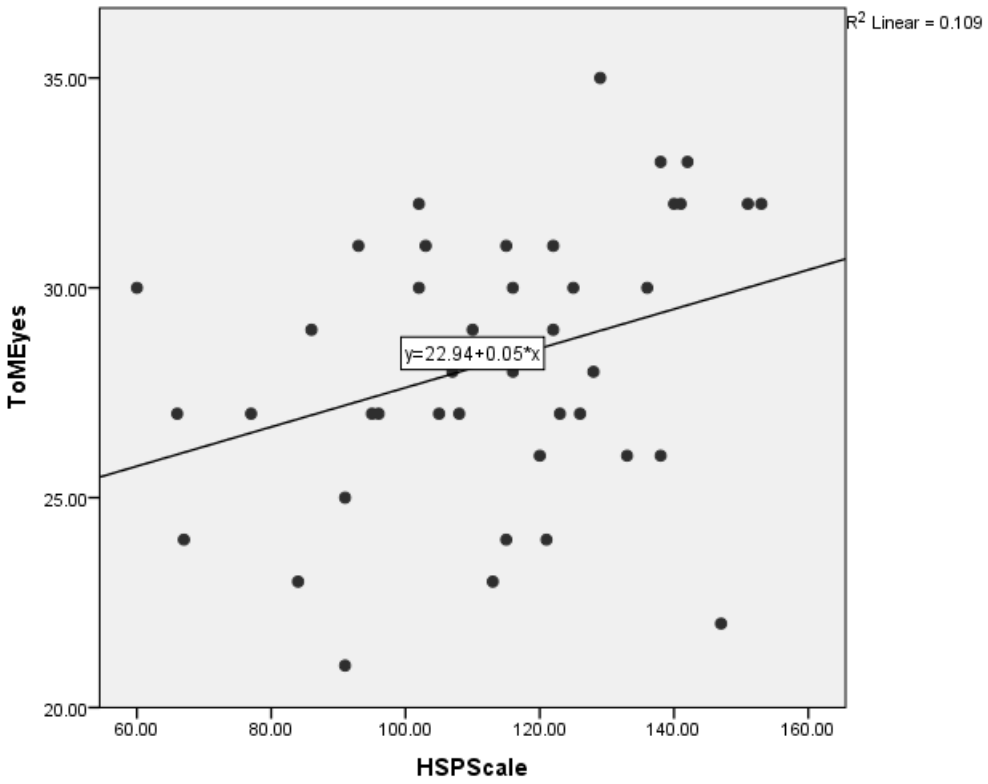
The aim of the present experiment was to investigate SPS in relation to empathy and ToM. This was achieved through examining the effect of SPS on level of empathy and ToM. The present experiment also aimed to

examine the effect of colour perception on SPS. Colour acuity and ToM was also examines to find out whether Experiment 4 (Chapter 8) results could be replicated. See Table 1 for the descriptive statistics and Figure 1 for graphs displaying the significant relationships between SPS and emotional and cognitive empathy, emotional empathy, and ToM.

Table 1: Means and Standard Deviations for each Variable

Variable	***Name of Test***	***Mean***	***SD***	***Range (Actual scores)***	***Range (Possible scores)***
Colour Perception	Farnsworth-Munsell 100 Hue Colour Vision Test (Farnsworth, 1957)	25.86	35.17	0-150	0->100
Emotional & Cognitive Empathy	Interpersonal Reactivity Index (IRI; Davis, 1983)	71.33	14.40	27-100	0-112
Emotional Empathy	Toronto Empathy Questionnaire (TEQ; Spreng et al, 2009)	46.90	8.64	22-60	0-64
Sensory Processing Sensitivity (SPS)	Highly Sensitive Person Scale (HSPS; Aron & Aron, 1997).	113.17	23.37	60-153	27-189
ToM Eyes	Reading the Mind in the Eyes Test, Revised Version (Baron-Cohen et al, 2001)	28.24	3.30	21-35	0-37

a)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30.00
25.00
20.00
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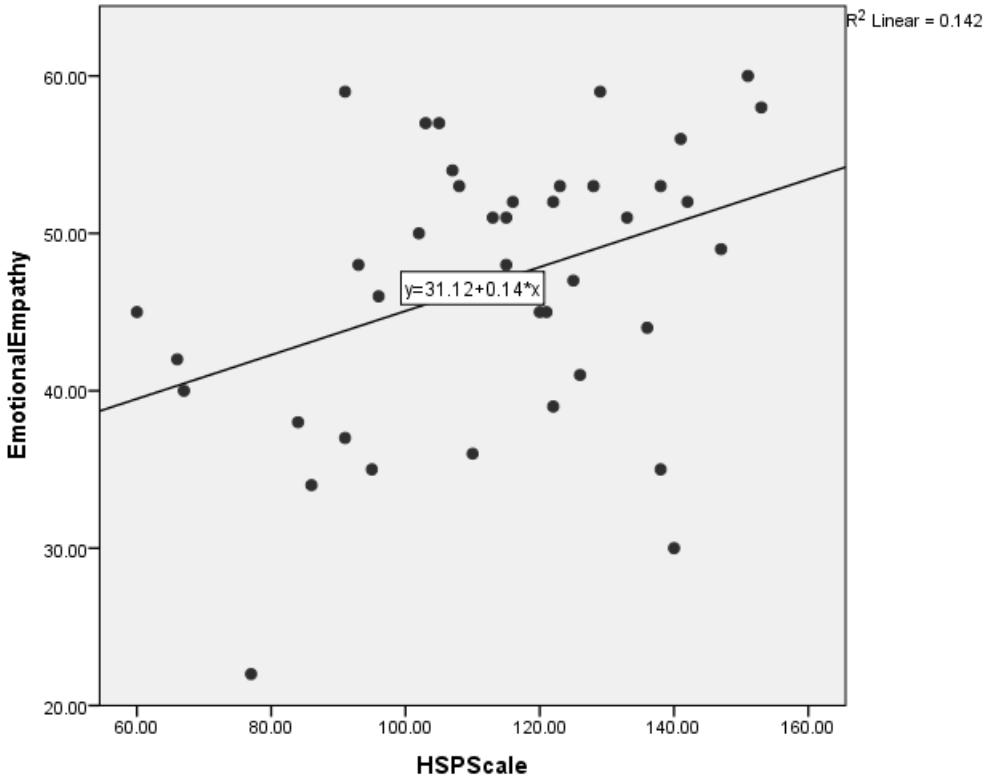
60.00
80.00
100.00
120.00
140.00
160.00
HSPScale

b)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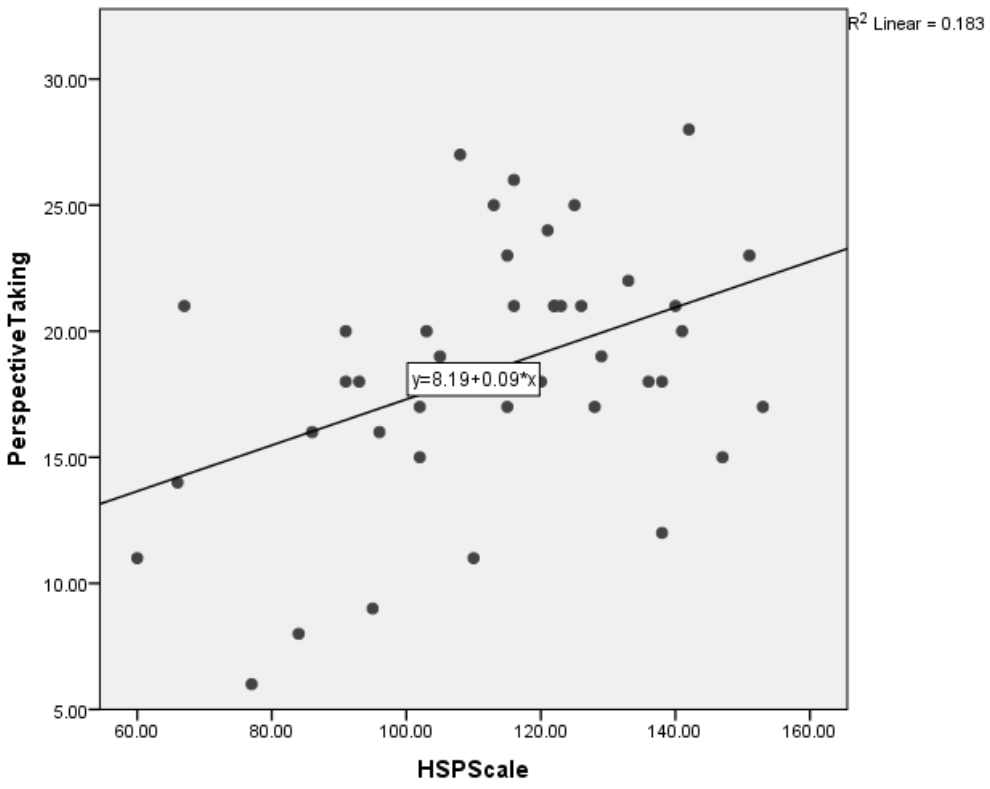
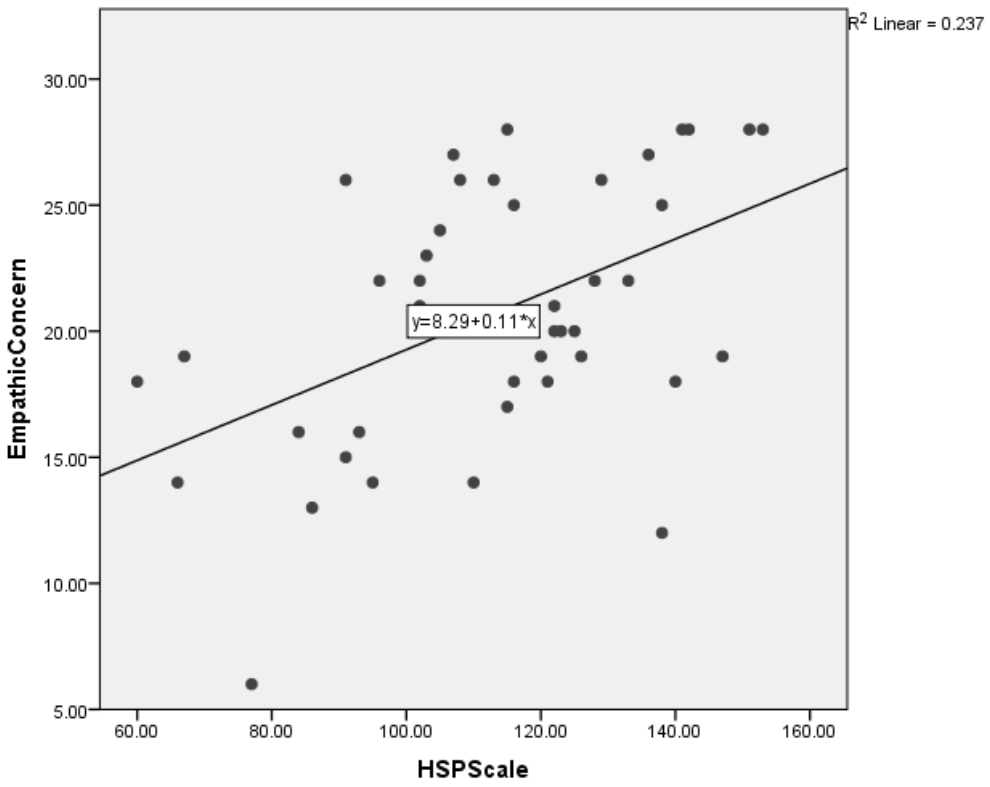
50.00
40.00
30.00
20.00
EmotionalEmpathy
y=31.12+0.14*x
60.00
80.00
100.00
120.00
140.00
160.00
HSPScale

c)

<u>Figure 1:</u> Scatterplots depicting the significant relationships between SPS and (a) emotional and cognitive empathy, (b) emotional empathy, and (c) ToM

A multivariate general linear model (GLM) was conducted with the dependent variables being the measures of emotional and cognitive empathy (IRI), emotional empathy (TEQ), and score on ToM Eyes. The covariate was the measure of SPS (HSPS). The analysis revealed significance ($F(3, 38) = 10.60$, $p < 0.001$), showing a main effect of SPS on the empathy and ToM measures. Significance was found in emotional and cognitive empathy ($F(1,40) = 29.93$, $p < 0.001$), emotional empathy ($F(1,40) = 6.64$, $p < 0.05$), and ToM ($F(1,40) = 4.92$, $p < 0.05$). Figure 2 demonstrates the significant effect of SPS on the IRI subscales.

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HSPScale
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20.00
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10.00
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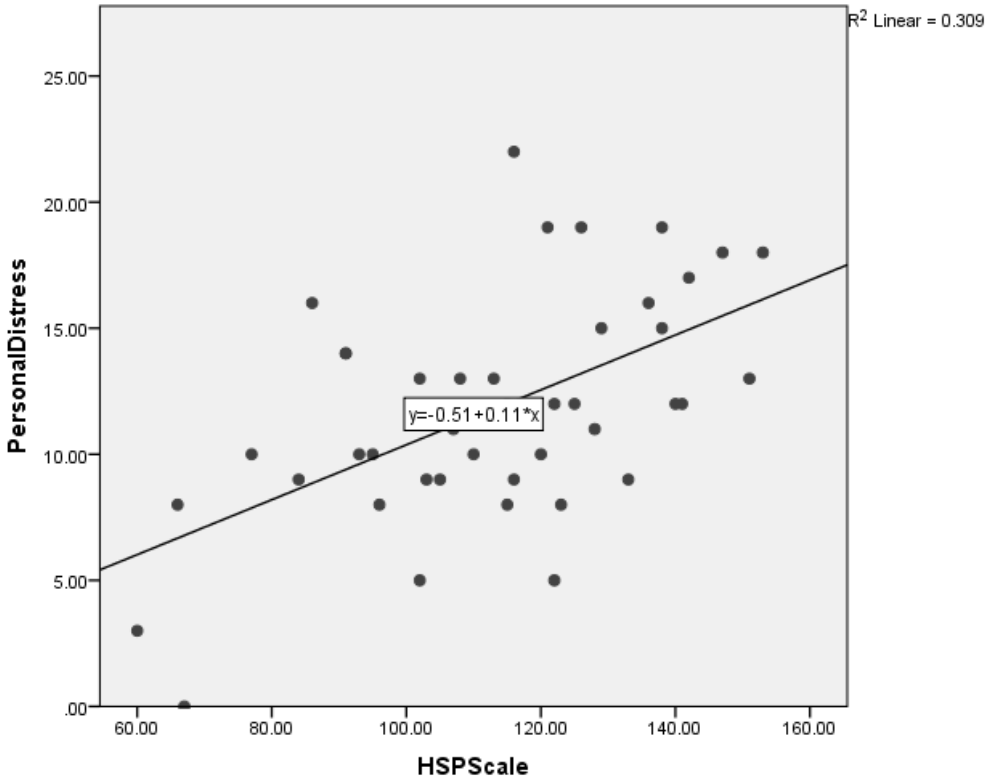
120.00
140.00
160.00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20.00
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5.00
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60.00
80.00
100.00
120.00
140.00
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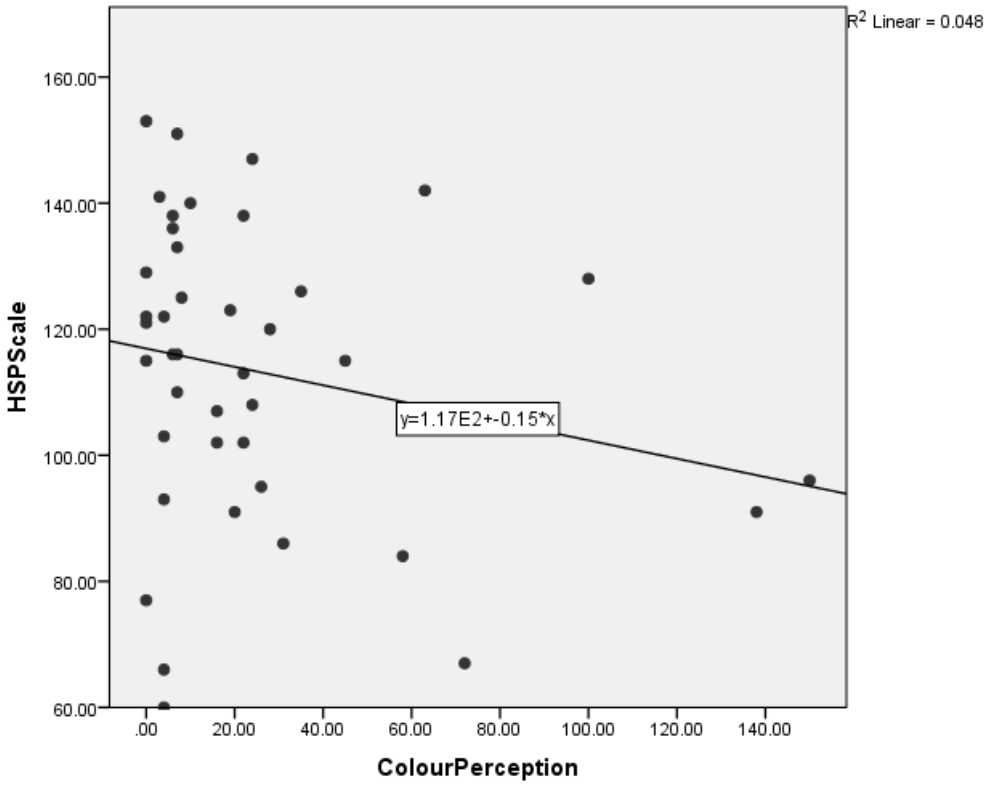
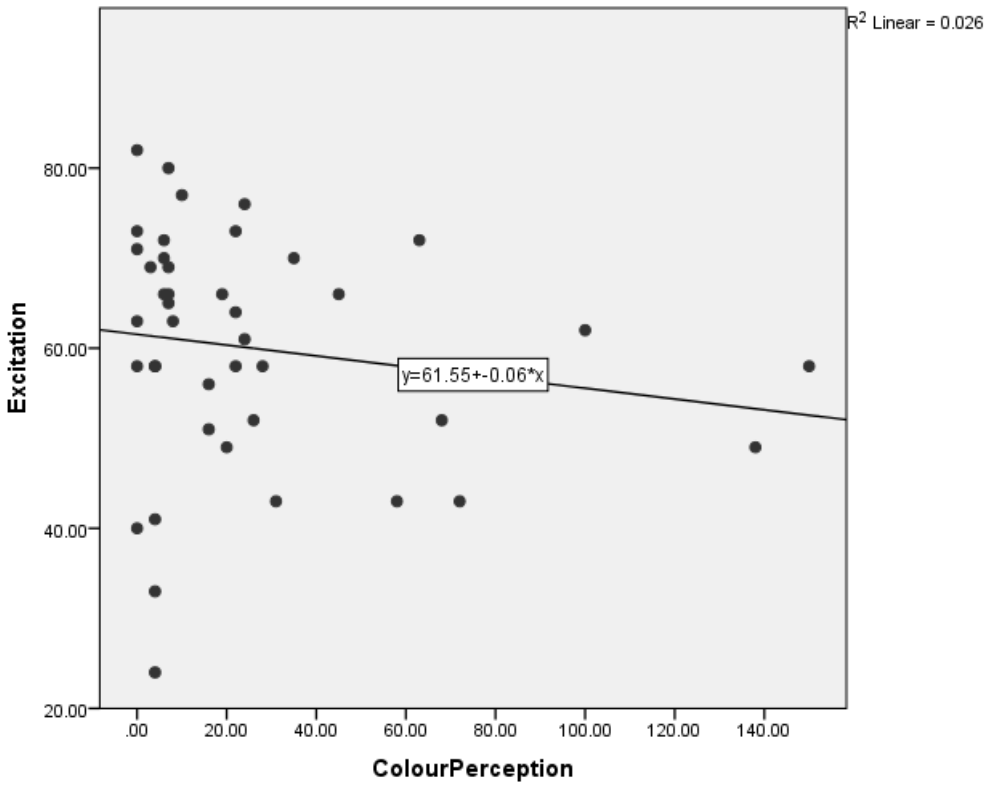
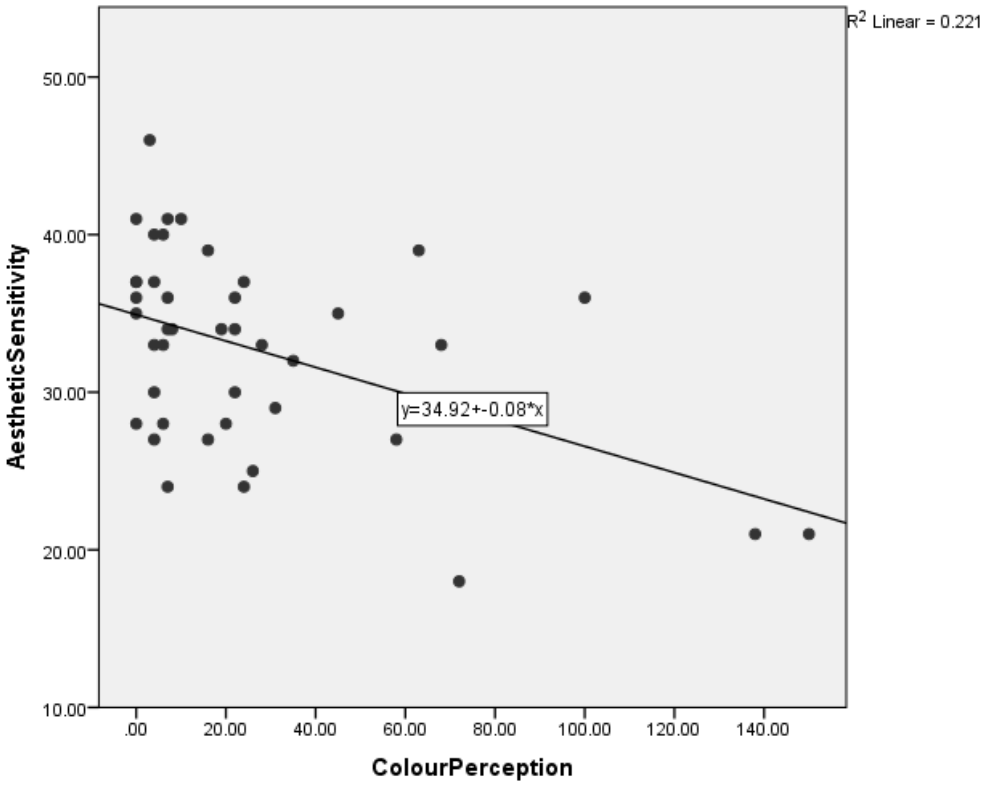
<u>Figure 2:</u> Scatterplots depicting the significant relationships between SPS and emotional and cognitive empathy measures

Exploratory analysis was used to further analyse the subscales of the measure of emotional & cognitive empathy (IRI) (these included: perspective taking (cognitive), fantasy (cognitive), empathic concern (emotional), and personal distress (emotional). A multivariate analysis revealed significance with SPS (HSPS) as the covariate ($F(4, 37) = 9.05$, $p < 0.001$). Significance was found in perspective taking ($F(1, 40) = 8.95$, $p < 0.005$), empathic concern ($F(1, 40) = 12.45$, $p < 0.001$), and personal distress ($F(1, 40) = 17.90$, $p < 0.001$). Figures 3 and 4 demonstrate the significant effect of colour perception on SPS and the HSPS subscales.



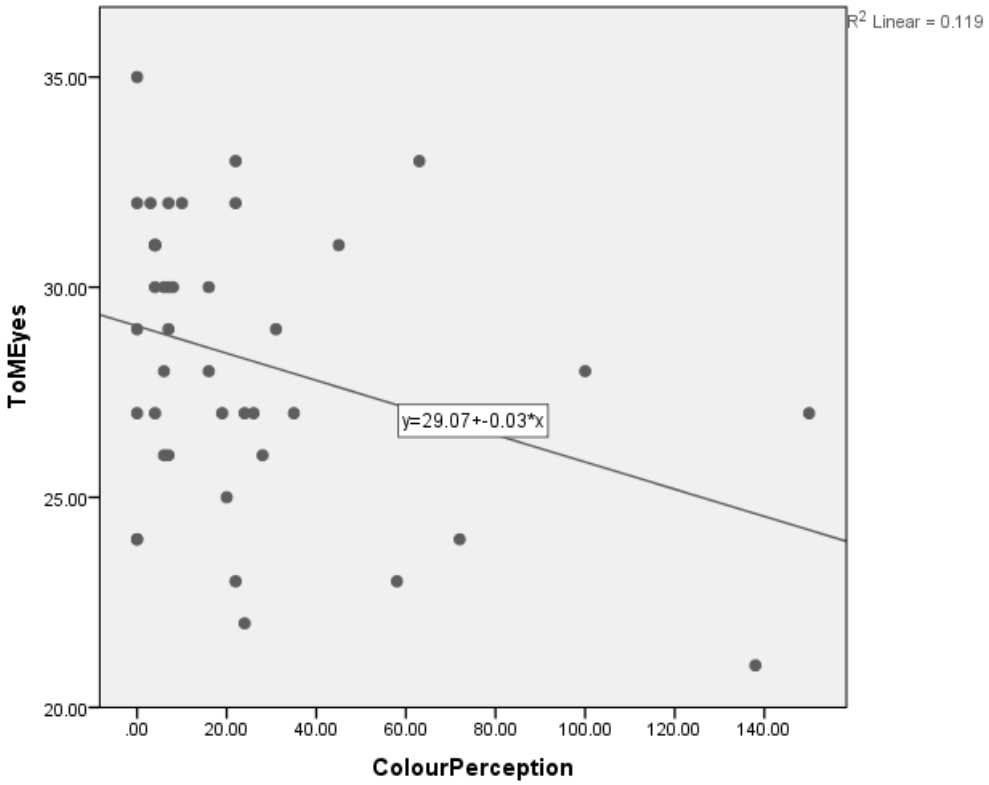
<u>Figure 3:</u> Scatterplot depicting the significant relationship between colour perception and SPS (HSPS)





<u>Figure 4:</u> Scatterplot depicting the significant relationship between colour perception and HSPS subscales

The data on colour perception was found not to be normally distributed, Shapiro-Wilkes was < 0.05, therefore a Wilcoxon test was conducted with the dependent variable being SPS (HSPS) and the independent variable being colour perception. This revealed a significant difference in SPS based on colour perception ($Z = -5.50$, $p < 0.001$). The median score for SPS was 115.50, and the median for colour perception was 13.00. Exploratory analysis was conducted into the subscales of the HSPS (these are: ease of excitation, aesthetic sensitivity, and low sensory threshold). A multicollinearity analysis was run and this revealed that the three subscales to do not show multicollinearity, thus independence was assumed and three separate Wilcoxon tests were conducted. A Bonferroni correction of 0.017 was applied. The analyses revealed significance differences in excitation ($Z = -4.20$, $p < 0.001$) and in aesthetic sensitivity ($Z = -2.42$, $p < 0.017$) based on colour perception. The median score for excitation was 62.50 and the median score for aesthetic sensitivity was 34.00. However, no significant difference was found in low sensory threshold ($Z = -0.61$, $p > 0.017$).



<u>Figure 5:</u> Scatterplot depicting the significant relationship between colour perception and ToM Eyes

Linear regression was conducted to determine whether colour acuity is a significant predictor of ToM Eyes. Colour perception was entered into SPSS as the independent variable, with ToM Eyes as the dependent variable. The results revealed significance and are in accordance with those found in Experiment 4, Chapter 8 ($R^2 = 0.12$, $F(1,40) = 5.38$, $p < 0.05$), indicating that colour acuity significantly predicted ToM Eyes ($\beta = - 0.34$, $t = 2.32$, $p < 0.05$).

In summary, the results show a significant effect of SPS (HSPS) on emotional and cognitive empathy (IRI), emotional empathy (TEQ), and ToM Eyes scores, hence those who scored high in SPS also score high in these measures. Looking into the subscales of the emotional and cognitive

measure (IRI) revealed a significant effect of SPS on perspective taking, empathic concern and personal distress, but not fantasy, suggesting that those who score high in SPS score higher in perspective taking, empathic concern and personal distress. The results on colour perception show a significant difference in SPS based on colour acuity, indicating that those with better colour perception score higher in SPS. Looking into the subscales of the HSPS revealed that colour acuity had a significant effect on excitation and aesthetic sensitivity, but not the low sensory threshold subscale, which shows that those with better colour perception score higher in excitation and aesthetic sensitivity. Colour acuity was found to be a significant predictor of ToM Eyes, replicating the results of Experiment 4 (Chapter 8), highlighting the strength and robust nature of this finding.

9.4 Discussion

The findings of the current experiment provide support for the hypothesis that individuals high in SPS will score significantly higher on measures of empathy and ToM. Specifically, the current findings show that there is an effect of SPS on emotional and cognitive empathy, emotional empathy, and ToM, showing that individuals high in SPS also score higher on the empathy and ToM measures. Furthermore, the exploratory analysis of the emotional and cognitive empathy subscales (perspective taking (cognitive), fantasy (cognitive), empathic concern (emotional), and personal distress (emotional)) revealed a significant difference in all subscales, except fantasy, based on SPS, indicating that those high in SPS score higher in these empathy subscales. The current findings do support the second hypothesis that individuals with more acute colour perception will score

higher in SPS. Furthermore, exploratory analysis of the subscales of the HSPS (ease of excitation, aesthetic sensitivity, and low sensory threshold; Appendix 10) does reveal a significant difference in excitation and aesthetic sensitivity based on colour acuity (those scoring high in colour perception also scored high in these subscales), but no significant difference in the low sensory threshold subscale was found. Moreover, colour acuity was found to be a significant predictor of ToM Eyes, replicating the results of Experiment 4 (Chapter 8), highlighting the strength and robust nature of this finding.

The current behavioural findings, showing that individuals high in SPS score significantly higher on empathy and ToM measures, are consistent with the previous findings of an fMRI study which has shown scores on the HSPS (Appendix 10) to be associated with brain regions involved in empathy (including a region of the mirror neuron system – the inferior frontal gyrus) (Acevedo et al, 2014). Both emotional empathy and cognitive empathy are shown to be linked to mirror neurons and embodiment (Gazzola et al, 2006; Kaplan & Iacoboni, 2006; Pfeifer et al, 2008; Shamay-Tsoory et al, 2009). Another study also provides support of the current findings (Jagiellowicz et al, 2016). The study examined the association between emotional responses to images (positive, negative and neutral) from the International Affective Picture System and SPS measured via the HSPS in a sample of 96 participants. Those high in SPS rated emotional pictures as being more valenced, especially positive images, than those low in SPS. They also responded faster to the positive images. Moreover, high compared to low SPS individuals who reported having high-quality parenting, reported greater arousal in response to the positive images (Jagiellowicz et al, 2016). These

studies therefore show that those high in SPS have stronger emotional reactions to images than those low in SPS. Within the exploratory analysis of the emotional & cognitive measure (IRI; Appendix 5), all subscales, except the fantasy subscale, revealed a significant effect of SPS within the current study, indicating that those who scored high in SPS scored high in the empathy subscales apart from fantasy. Perhaps this is because the fantasy subscale may be a better assessment of imagination as opposed to the theoretically driven notions of empathy (Baron-Cohen & Wheelwright, 2004; Spreng et al, 2009) which is worthy of further study.

In relation to the findings on colour perception and SPS, there was a significant difference in SPS based on colour acuity, in which those with higher colour acuity scored higher on the measure of SPS. This is not surprising since previous results from experiments of this thesis (Experiments 3 and 4: Chapters 7 and 8) has shown colour acuity to be a significant predictor of empathy and ToM Eyes, and SPS in the present study has been shown to affect both of these. Both Experiments 3 and 4 utilised the same measure of colour perception and measures of empathy and ToM as the current study. Moreover, in the current experiment, investigation into the subscales of the HSPS (Appendix 10) has revealed excitation and aesthetic sensitivity to be significantly increased for individuals who have better colour perception. Previous research (Ahadi & Basharpoor, 2010; Liss et al, 2008; Sobocko & Zelenski, 2015) into the subscales of the HSPS have shown aesthetic sensitivity to be related to more positive and beneficial outcomes than the ease of excitation and low sensory threshold subscales, and having a more acute colour perception is presumably a beneficial and

desirable attribute. In particular, aesthetic sensitivity has been shown to be associated with positive affect and openness to experience in a sample of 200 psychology student who completed online questionnaires measuring demographics, sensitivity, personality and well-being (Sobocko & Zelenski, 2015). Conscientiousness was also associated with aesthetic sensitivity in a sample of 180 participants who completed questionnaires on sensitivity, personality and mental health (Ahadi & Basharpoor, 2010). Moreover, greater attention to detail and good communication was related to aesthetic sensitivity in a sample of 201 college students measured for sensitivity, anxiety, depression, alexithymia, and autism symptoms (Liss et al, 2008). Studies into genotyping show SPS to be associated with the serotonin (Licht et al, 2011) and dopamine (Chen et al, 2011) systems, showing SPS to be involved in social cognition. Specifically, high scores on the HSPS were associated with the short(s), low-expressing variant of the repeat length polymorphism 5-HTTLPR (serotonin transporter, 5-HTT, Linked Polymorphic Region) (Licht et al, 2011), and Chen et al (2011) looked at all the genes (98) with polymorphisms that affect the dopamine system in relation to SPS and found a set of 10 loci on seven genes that predicted 15% of the variance of HSPS scores. Interestingly, dopamine is also involved in cognitive empathy (Lackner et al, 2010; Uzefovsky et al, 2014), and in colour perception (Banaschewski et al, 2006; Colzato et al, 2014; Hulka et al, 2013; Tannock et al., 2006), and linking these together is an important next avenue of research.

In conclusion, the present study has shown that SPS has a significant effect on level of empathy and ToM; specifically that highly sensitive

individuals have higher empathy levels. This was shown for emotional and cognitive empathy taken as a whole, emotional empathy, ToM, perspective taking, empathic concern, and personal distress. These findings suggest that SPS does have important implications for social cognition and may be beneficial in various contexts, as contrary to much previous research (Aron & Aron, 1997; Benham, 2006; Liss et al, 2005; Meyer & Carver, 2000; Neal et al, 2002), the current study shows SPS have beneficial outcomes such as enhanced social cognition, specifically increased empathy and ToM. Furthermore, importantly and in keeping with the aims of the thesis regarding colour perception, the current experiment revealed a significant effect of colour acuity on SPS, and the subscales excitation and aesthetic sensitivity, but not low sensory threshold. This suggests that certain perceptual abilities may affect various types of sensitivities, and this should be studied further. For example, future studies should investigate other forms of perception, for example, visual perception and taste perception in relation to SPS. Also, the results of the current study should be replicated using physiological measurements. To conclude, the important results of the study of this Chapter has strong implications for clinical disorders such as autism, and may explain why autism is linked to sensory processing disorder (Kern et al, 2006). The results of Experiment 4 (Chapter 8) were also replicated, showing colour acuity to be a significant predictor of ToM for the Eyes Test. The next study focuses on the effects of age on aspects already studied within this thesis, namely, colour perception and empathy, as well as looking into the effect of age in relation to preference for paintings.

9.5 Chapter Highlights

- SPS refers to the extent to which an individual is sensitive, or responsive, to their surroundings, including both environmental (weather, smells, noises) and social (crowded spaces, conflict among others, others' moods) stimuli.
- SPS is measured by the HSPS.
- The HSPS comprises of three subscales, these are: (i) Ease of Excitation, (ii) Aesthetic Sensitivity, and (iii) Low Sensory Threshold.
- Much research has tended to focus on its negative aspects of SPS.
- Of all the subscales of the HSPS, aesthetic sensitivity is related to more positive and beneficial outcomes.
- Acevedo et al (2014) has found a link between SPS and empathy.
- The aims of the current study were to examine whether there was an effect of SPS on level of empathy, and to examine whether there was an effect of colour acuity on SPS.
- The sample consisted of 42 adult participants.
- Measures included self-reports and tests of cognition and perception.
- Results revealed that those who scored highly in SPS scored high on measures of empathy and ToM, and those with better colour perception scored higher in SPS.
- Colour acuity was also found to be a predictor of ToM Eyes, replicating the results of Experiment 4 (Chapter 8).
- The current findings provide support for the hypotheses and previous research.

- The study should be replicated using physiological measures, and other types of perception (taste, smell) could also be examined.
- The study has implications for clinical disorders such as autism.

Chapter 10: The Effects of Age on Colour Perception, Empathy and Preference for Paintings

10.1 Introduction

The previous chapter (Chapter 9) has focused on sensory processing sensitivity (SPS), empathy/ToM and colour perception, showing that those who scored highly in SPS scored high on measures of empathy and ToM, and those with better colour perception scored higher in SPS. These are important findings as they show how SPS is linked to positive traits and is not merely related to negative ones such as stress, anxiety and depression, to name some examples. This therefore, bridges a gap in the literature and brings a greater understanding of SPS in general. The present study looks into the effects of age in relation to colour perception, empathy and preference for paintings. This is particularly important because many things (including cognition) change with age, and is important to rule out age as an extraneous variable within the current thesis.

There seems to be a symmetry to human physical life, as individuals whom are young and middle aged are independent and robust, whereas those in infancy and old age are frail and dependent. Thus, cognition appears to follow the pattern of building up and wearing down (Craik & Bialystok, 2006). The effects of age are apparent throughout the lifespan. The current study looks into the effects of age in relation to colour perception, empathy, and preference for paintings. A number of visual functions change with age, such as light sensitivity, susceptibility to glare,

colour perception, static and dynamic acuity, peripheral, vision and depth perception (Ishihara et al, 2001). Studies have shown that performance on the Farnsworth-Munsell 100 Hue Test (Appendix 3) varies as a U-shape function of age, with children having higher total error scores than adults in their 20s, and performance for older adults deteriorating with age (Kinnear & Sahraie, 2002; Roy et al, 1991; Verriest et al, 1982).

Empathy allows the individual to feel and understand the affective experiences of another by sensing their feelings (emotional empathy) and/or understanding their perspective (cognitive empathy) (Shamay-Tsoory, 2011). In relation to age, there seems to be mixed results regarding the previous research, suggesting age-related gains (Sze et al, 2012), longitudinal stability (Grühn et al, 2008), and cohort decline (Grühn et al, 2008; Phillips et al, 2002; Ruffman et al, 2008; Schieman & Van Gundy, 2000) in empathy and emotional recognition. Age differences in empathy have also been found to be context dependent (Wieck & Kunzmann, 2015), as have age differences in emotion recognition (Richter et al, 2011). For example, Wieck and Kunzmann (2015) found that there were age related deficits in empathy only when the task was of little relevance to the older adults, and Richter et al (2011) found that when younger and older women watched film clips featuring happiness, sadness, or anger, with or without sound, age-related deficits were only found for the films without sound. One particular study has found evidence for an inverse-U-shaped pattern across age, where middle-aged adults reported higher empathy than both young adults and older adults (O'Brien et al, 2013).

There does not seem to be much research into the effect of age on preference for paintings, especially focusing on portraits compared to landscapes. However, one particular study has looked into artistic preferences and individual differences (including the big five personality traits: extraversion, conscientiousness, neuroticism, agreeableness and openness to experience, and sex and age) in a sample of 91,692 participants (60% women and 40% men), aged 13–90 years (Chamorro-Premuzic et al, 2009). It was found that the personality trait openness to experience was the strongest correlate of artistic preferences for overall preferences (all paintings) and specific preferences (specific art movements including: abstract, cubism, Northern renaissance, Japanese ukiyo-e woodblock prints, impressionism, secular Islamic art). However, overall preferences were also positively influenced by age and visits to art galleries, as well as artistic self-perception and conscientiousness (negatively) to a lesser degree. For specific preferences, higher preference levels for impressionism were found for those who reported being more agreeable, more conscientious and less open. Those who were younger and more extraverted showed higher levels of preference for cubism (as did males), and younger participants and males reported higher levels of preferences for renaissance (Chamorro-Premuzic et al, 2009). Another similar study examining 121 participants found age to be significantly positively correlated with positive ratings of representational art (Furnham & Walker, 2001).

The current study aims to determine whether there is an effect of age on colour perception (colour acuity), empathy (for emotional empathy and for emotional and cognitive empathy taken as a whole), and preferences for

paintings (specifically, do people prefer portraits or landscapes? Which is particularly important since empathy relates to social interaction, which can be related to portrait liking/disliking). Freedberg and Gallese (2007) propose a theory comprised of two notions: the first concerning empathy felt through the content and subject matter of art, and the second concerning empathy felt through the way in which the artist creatively uses their materials to convey a representation. No interesting effects were found in relation to empathy and genre (history paintings, portraiture, genre paintings, landscape, still life, abstract) of paintings, thus the effects of age were studied. The study comprises of self-report measures and a test of perception. Exploratory analysis is used to examine the four subgroups of the measure of emotional and cognitive empathy. These include: (i) perspective taking (cognitive), (ii) fantasy (cognitive), (iii) empathetic concern (emotional), and (iv) personal distress (emotional). It is hypothesised that there will be an effect of age on colour perception, with performance deteriorating as age increases, as suggested by previous research (Kinnear & Sahraie, 2002; Roy et al, 1991; Verriest et al, 1982). Although empathy and age research has provided mixed results, the majority does seem to suggest that while there may be no differences longitudinally, there are declines in empathy and emotion recognition with age in cohort designs (Grühn et al, 2008; Phillips et al, 2002; Ruffman et al, 2008; Schieman & Van Gundy, 2000), therefore, the second hypothesis is that there will be a significant difference in empathy scores based on age, with younger participants being more empathetic than older ones. Lastly, and most importantly due to its novelty, it is also hypothesised that there will be effect

of age on preference for portraits compared to landscapes. Whilst there is currently no research to suggest that this will be the case, this is predicted because empathy levels may increase or decrease with age, and if so, those who are more empathetic may prefer to look at images of people more than landscapes. However, the opposite could also occur, as more empathetic people may feel more relaxed looking at the landscapes, and therefore prefer them to the portraits.

10.2 Method

10.2.1 Participants

A total of 42 individuals, from two separate data sets (including the data from Chapter 9), including 6 males and 36 females with an age range of 18 to 62 (mean = 25.83), participated in the study. Exclusion criteria was no uncorrectable vision problems, including colour blindness.

10.2.2 Design

A within subjects design was utilised whereby all participants were exposed to the same conditions. The data was analysed through a general linear model. All measures were standardised.

10.2.3 Materials

10.2.3.1 Self-reports

Interpersonal Reactivity Index (IRI; Davis, 1983; Appendix 5)

See Chapter 5 for details.

Participant Demographic Details

Participants were asked their age, gender and handedness.

Responses to Paintings

This consisted of 42 Likert scales ranging from one to six, one being 'I do not like it at all' and six being 'I like it very much'.

Toronto Empathy Questionnaire (TEQ; Spreng et al, 2009; Appendix 9)

See Chapter 5 for details.

10.2.3.2 Test of Colour Perception

Farnsworth-Munsell 100 Hue Colour Vision Test (Farnsworth, 1957; Appendix 3)

See Chapter 7 for details.

10.2.3.3 Images

Paintings (Appendix 12)

The images of paintings consisted of 42 pictures, 21 portraits and 21 landscapes, each was shown on a separate slide. The height of each picture was made to fit the height of the slide. The height and width of each picture remained proportionate to the original painting. Paintings were chosen from seven different impressionist artists (Berthe Morisot, Camille Pissarro, Claude Monet, Edouard Manet, Hilaire-Germain-Edgar Degas, Paul Cézanne, Pierre-Auguste Renoir) to reduce an effect of style/artist/art movement. Six pictures were shown form each artist (three portraits and 3

landscapes). The images of paintings were mixed up and shown in random order to reduce order effects.

10.2.4 Procedure

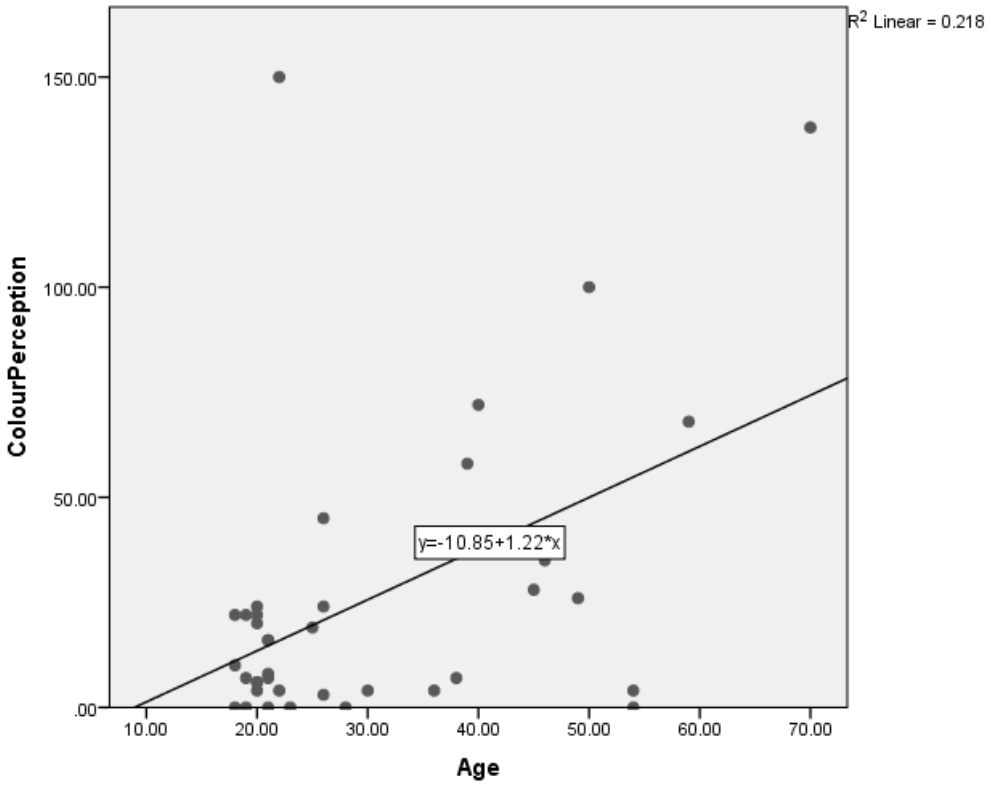
The study took place at the University of Bradford within an experimental cubicle. On arrival participants firstly gave informed consent. They then filled out some demographic details and completed was the Farnsworth-Munsell 100 Hue Colour Vision Test (Farnsworth, 1957; Appendix 3), followed by the measure of emotional and cognitive empathy, specifically, the Interpersonal Reactivity Index (Davis, 1983; Appendix 5). Next, the participants looked at images of paintings (Appendix 12) and completed six-point Likert scales rating the extent to which they liked each image, one being 'I do not like it at all' and six being 'I like it very much'. Once all the tasks were completed, participants were given the opportunity to ask questions. Tasks requiring the most attention and concentration were presented first. Ethical approval was granted from the Chair of the Humanities, Social and Health Sciences Research Ethics Panel, University of Bradford.

10.3 Results

The present study aimed to examine whether there was an effect of age on colour perception, empathy and preference for portraits. See Table 1 for descriptive statistics.

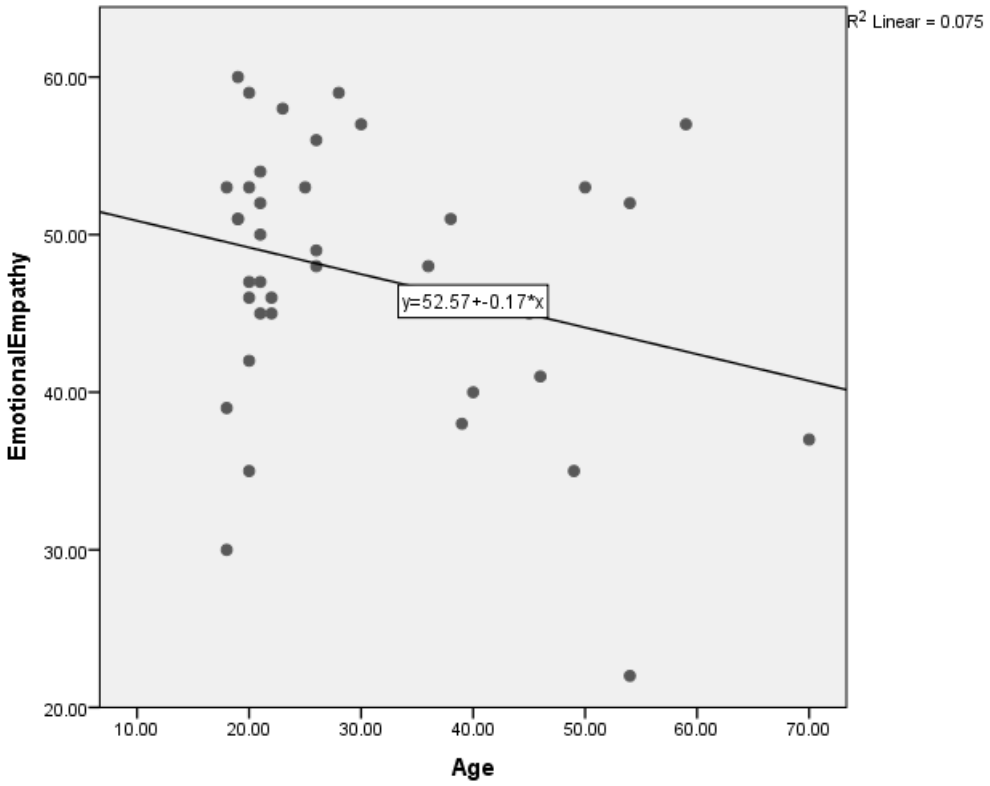
Table 1: Means and Standard Deviations for each Variable

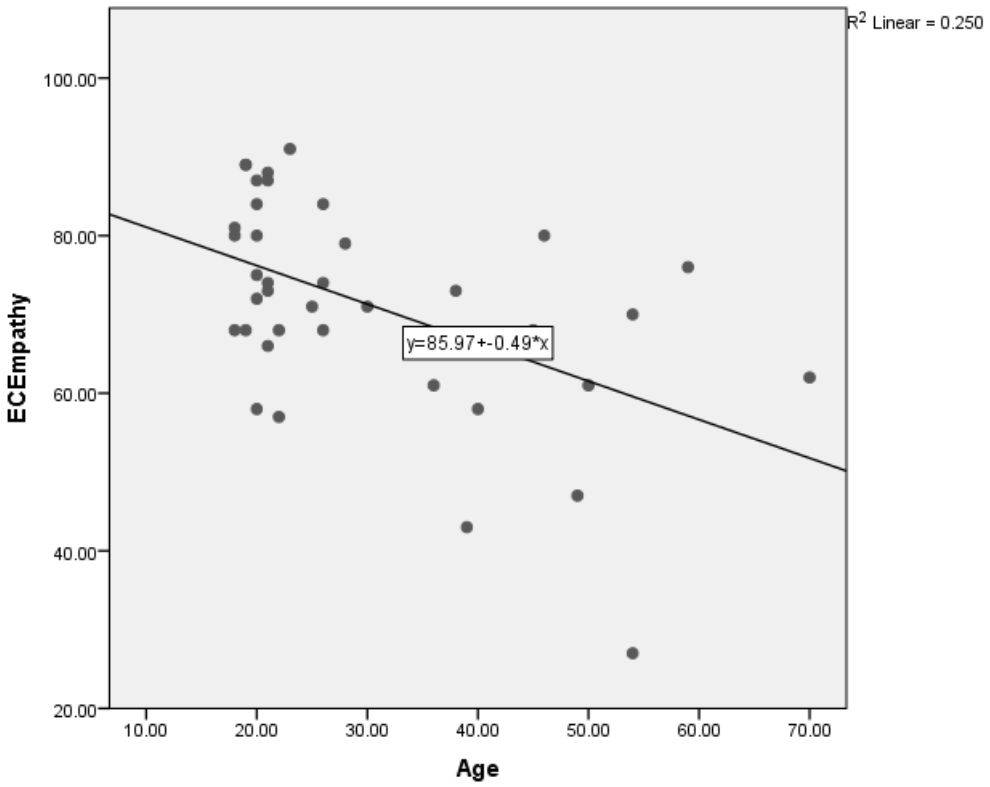
Variable	***Name of Test***	***Mean***	***SD***	***Range (Actual scores)***	***Range (Possible scores)***
Age	Participant Demographic Details	28.00	12.05	18-70	18+
Colour Perception	Farnsworth-Munsell 100 Hue Colour Vision Test (Farnsworth, 1957)	25.85	35.17	0-150	0->100
Emotional & Cognitive Empathy	Interpersonal Reactivity Index (IRI; Davis, 1983)	71.33	14.40	27-100	0-112
Emotional Empathy	Toronto Empathy Questionnaire (TEQ; Spreng et al, 2009)	46.90	8.64	22-60	0-64
Preference for Portraits	Responses to Paintings	47.50	7.58	-77-40	-252-504



<u>Figure 1:</u> Scatterplot depicting the significant relationships between colour acuity and age. A lower colour perception score indicates better/more acute colour perception. It is clear from the two graphs that as colour perception becomes less acute, age increases.

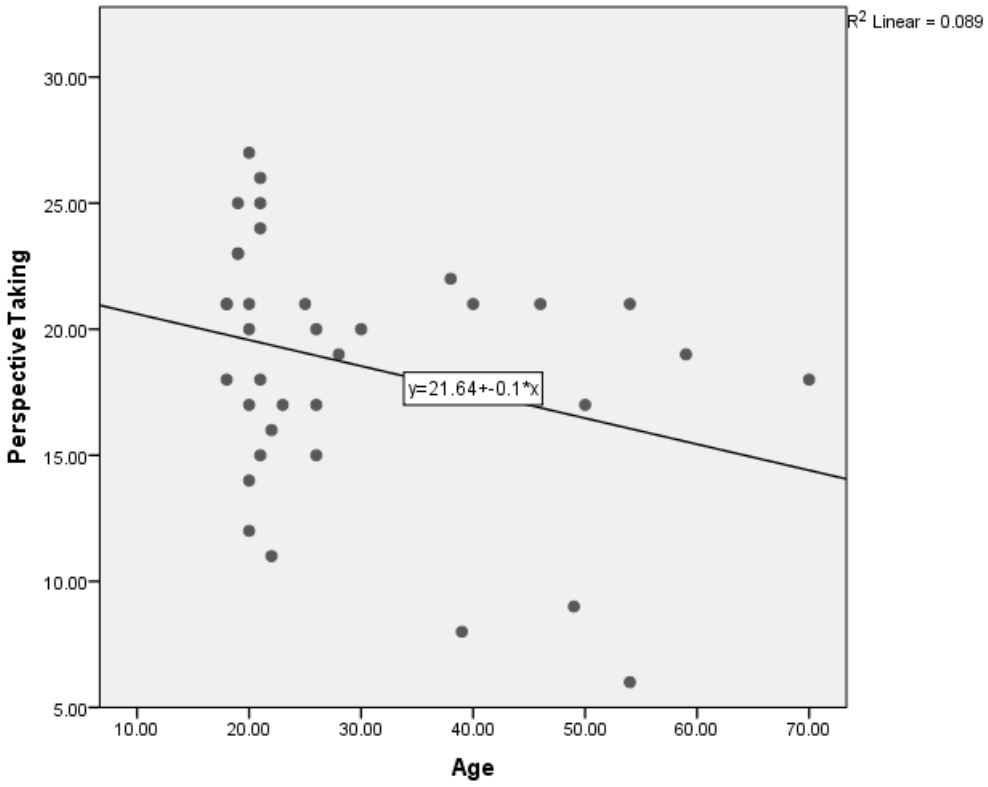
The data on colour perception and age was found not to be normally distributed, Shapiro-Wilk was < 0.05. Therefore, a Wilcoxon test was conducted to with the dependent variable being colour perception and the independent variable being age. This revealed a significant difference in colour perception based on age ($Z = -2.20$, $p < 0.05$). The median score for colour perception was 13.00, and the median for age was 22.50.

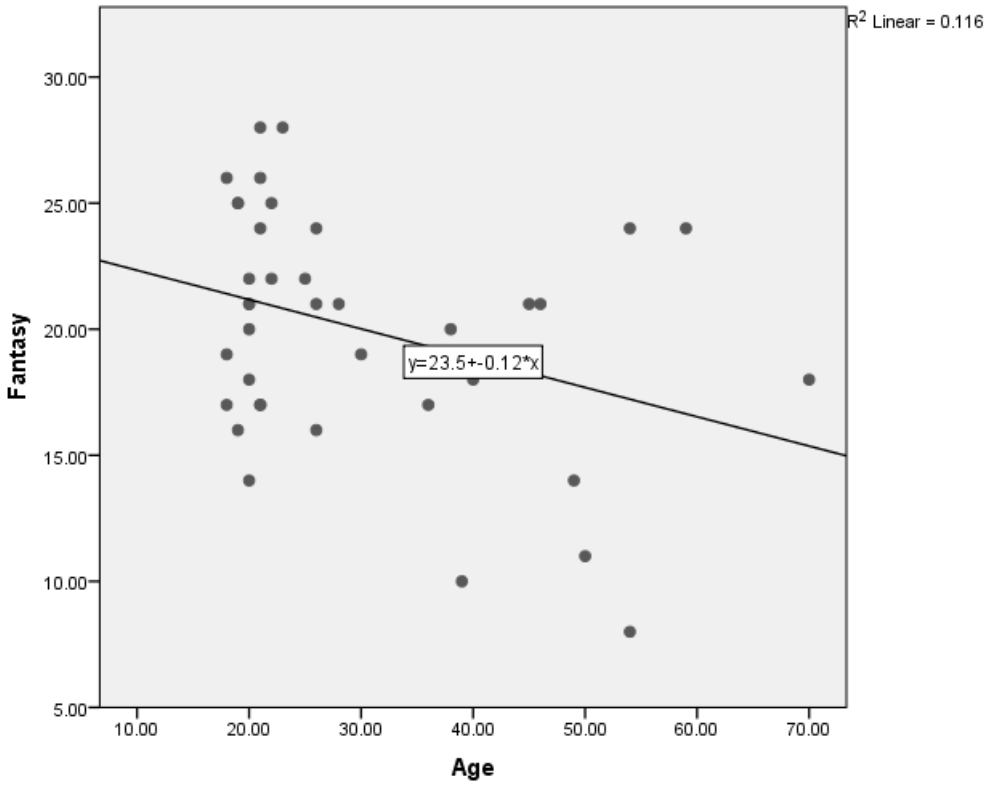




<u>Figure 2:</u> Scatterplots depicting the significant relationships between (i) emotional empathy and age and (ii) emotional and cognitive empathy and age

The data on emotional and cognitive empathy and age was found not to be normally distributed, Shapiro-Wilk was < 0.05. Therefore, two separate Wilcoxon tests were conducted to with the dependent variables being emotional empathy and emotional and cognitive empathy and the independent variable being age. This revealed a significant difference in emotional empathy based on age ($Z = -3.99$, $p < 0.001$), and a significant difference in emotional and cognitive empathy based on age ($Z = -5.17$, $p < 0.001$). The median score for emotional empathy was 48.00, the median score for emotional and cognitive empathy was 72.50, and the median for age was 22.50.

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Fantasy
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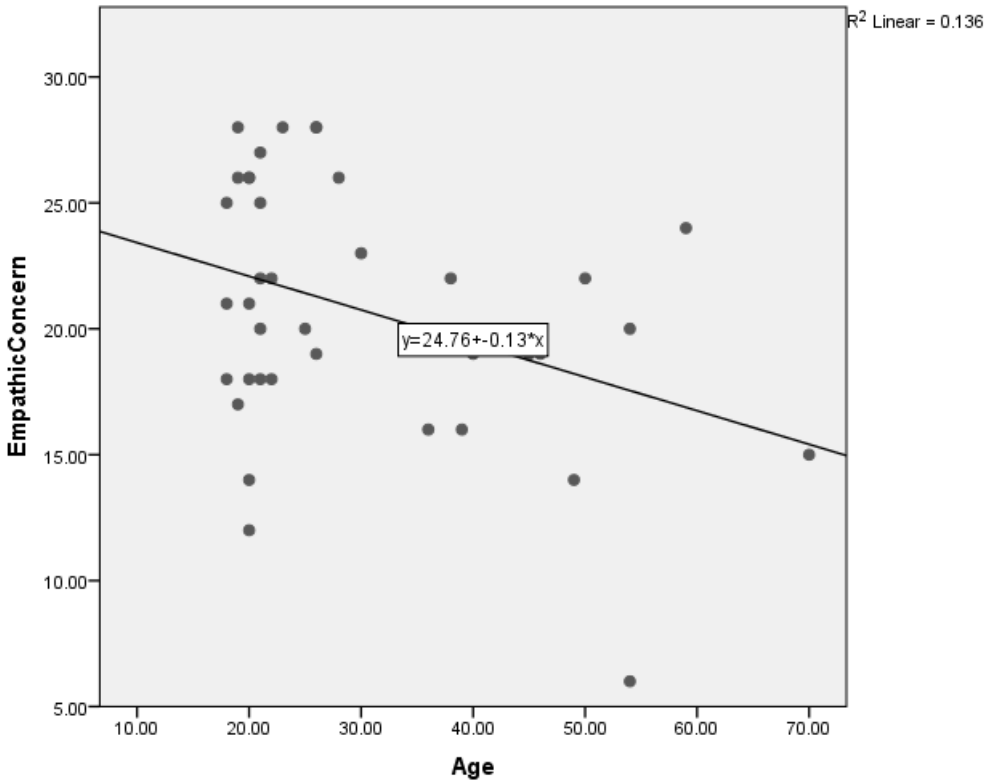
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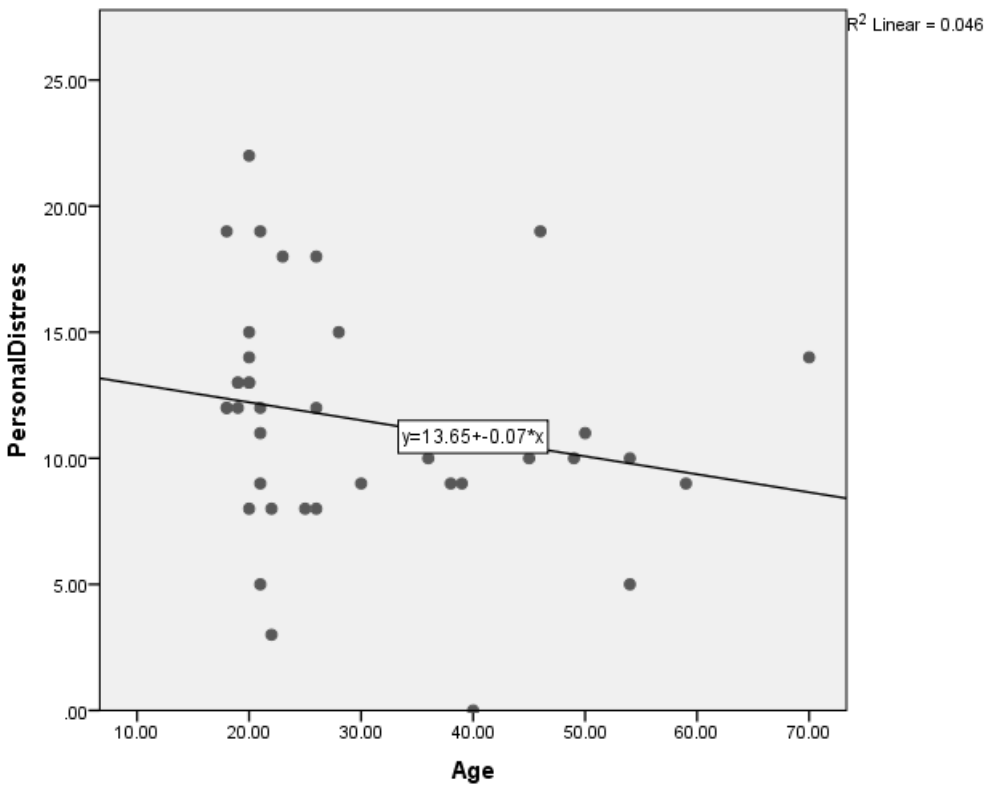
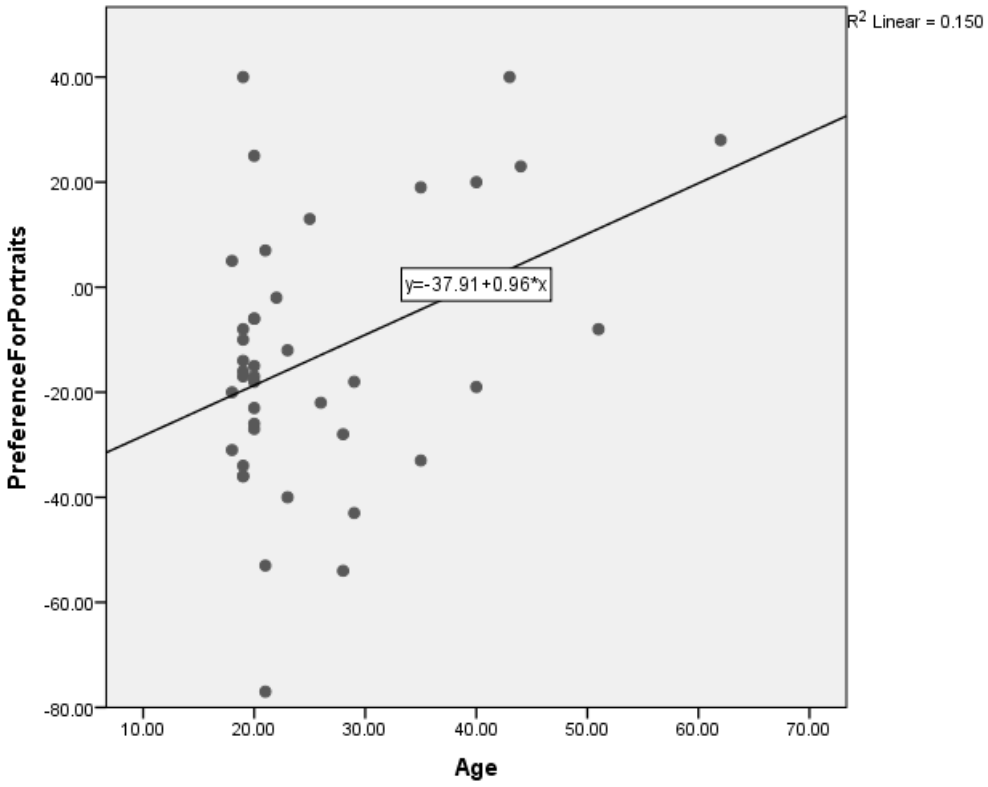


<u>Figure 3:</u> Scatterplots depicting the significant relationships between age and emotional and cognitive empathy measures

Exploratory analysis was used to further analyse the subscales of the measure of emotional & cognitive empathy (IRI) (these included: perspective taking (cognitive), fantasy (cognitive), empathic concern (emotional), and personal distress (emotional). Four separate Wilcoxon tests were conducted to with the dependent variables being IRI subscales and the independent variable being age. A Bonferroni correction of 0.0125 was applied. Significant differences were found in all subscales based on age, specifically, perspective taking ($Z = -3.95$, $p < 0.001$), fantasy ($Z = -3.02$, $p < 0.01$), empathic concern ($Z = -2.64$, $p < 0.01$), and personal distress ($Z = -5.32$, $p <$

0.001). The medians were 22.50 for age, 18.50 for perspective taking, 20.50 for fantasy, 20,50 for empathic concern, and 12.00 for personal distress.



<u>Figure 4:</u> Scatterplot depicting the significant relationship between preference for portraits and age

The data on age was found not to be normally distributed, Shapiro-Wilk was < 0.05. Therefore, a Wilcoxon test was conducted to with the dependent variable being preference for portraits and the independent variable being age. This revealed a significant difference in preference for portraits based on age ($Z = -5.52$, $p < 0.001$). The median score for preference for portraits was -16.50, and the median for age was 20.50.

10.4 Discussion

The findings of the current study do support the hypotheses in showing age to have an effect on colour perception, empathy and preference for paintings. Specifically, age was shown to effect colour perception suggesting that as age increases, colour acuity decreases, thus younger adults are shown to have better colour perception than older adults. Similarly, age was shown to have an effect on empathy, indicating that as age increases, empathy levels decrease. This was found for emotional empathy & emotional and cognitive as a whole. Exploratory analysis of the subscales of emotional & cognitive empathy measure (IRI; Appendix 5) also revealed the same pattern, showing that perspective taking (cognitive), fantasy (cognitive), empathic concern (emotional), and personal distress (emotional) all decrease as age increases. Lastly, age was shown to have an effect on preference for paintings, indicating that preference for portraits over landscapes increases as age increases.

The current findings on age and colour perception are in accordance with previous research which also suggests that colour perception deteriorates with age (Kinnear & Sahraie, 2002; Roy et al, 1991; Verriest et al, 1982). For example, Roy et al (1991) tested 115 normal North American subjects aged 5–81 years. Participants were measured on the Farnsworth-Munsell 100-Hue test and the Lanthony Desaturated Panel D-15 test, and it was found that colour discrimination was best between the ages of 20 and 50 years. Increasing age was associated with an increase in total error scores on the Farnsworth-Munsell 100-Hue test (Roy et al, 1991). Both Kinnear and Sahraie (2002) and Verriest et al (1982) show that performance on the

Farnsworth-Munsell 100-Hue test (Appendix 3) varies as a U-shape function of age. Verriest et al (1982) examined 232 normal participants between 10 and 80 years of age. Participants underwent both binocular and monocular testing. Performance was found to be worse during monocular testing and for those who had no previous experience with the task. Children and the elderly were also found to perform less well on the colour vision task (Verriest et al, 1982). Kinnear and Sahraie (2002) measured colour vision in an equal number of male and female participants aged from five–79 years of age. Participants completed the Farnsworth-Munsell 100-Hue test (Appendix 3) and it was found that younger children make more misplacement errors and therefore have higher total error scores than individuals in their 20s. The performance of older adults was also found to deteriorate with age (Kinnear & Sahraie, 2002).

The current findings on empathy indicated that all types of empathy (emotional empathy and emotional and cognitive empathy, as well as the subscales: perspective taking, fantasy, empathic concern, and personal distress) decrease as age increases. This finding is in line with much of the cohort literature which suggests that there is an age related decline in empathy and emotional recognition (Grühn et al, 2008; Phillips et al, 2002; Ruffman et al, 2008; Schieman & Van Gundy, 2000). However, although Grühn et al (2008) show cohort decline in empathy based on age, their findings also show that longitudinally (spanning 12 years) there seems to be no age related decline in empathy, thus suggesting a cohort rather than an age effect. Since the current study was not longitudinal, it is questionable as to whether or not the same would have been found. Contrary to the current

finding, other research has found age related gains in empathy (Sze et al, 2012). The study examined 70 older participants (60-80 years), 72 middle aged participants (40-50 years), and 71 young participants (20-30 years). Participants watched two films of individuals in need, one uplifting film and one distressing film. Physiological measures (cardiac and electrodermal measures) were taken during the films, and self-reported levels of emotional empathy were taken after each film. Prosocial behaviour was also measured by giving the participants a payment which they could contribute to charities supporting the individuals in the films. Age related increases were found for emotional empathy (self-reported empathic concern and cardiac and electrodermal responding) and prosocial behaviour (size of contribution) for both films, as well as for self-reported personal distress to the distressing film (Sze et al, 2012). In addition, a very large online study consisting of 75,263 participants, has found support of an inverse-U-shaped pattern across age (O'Brien et al, 2013). Ages ranged between 18 and 90. The study involved participants completing the IRI subscales of perspective taking and empathic concern. Middle-aged adults reported higher empathy than both young adults and older adults (O'Brien et al, 2013).

Furthermore, the relationship between age and empathy becomes more complicated due to the effect of context, as studies on both empathy and emotion recognition suggest that age differences in empathy are context dependent (Richter et al, 2011; Wieck & Kunzmann, 2015). Specifically, Wieck and Kunzmann (2015) found that age deficits in empathy were only apparent when the task was of little relevance to the older adults, there were no negative age differences if the task was highly relevant to the older

participants. The study investigated empathic accuracy (the ability to perceive another's emotions accurately), emotional congruence (the capacity to share another's emotions), and sympathy within a sample of 101 younger women (mean age 24) and 101 older women (mean age 69). They viewed six film clips of a younger and older woman reliving and thinking aloud about an autobiographical memory, the emotional quality consisted of anger, sadness, and happiness (Wieck & Kunzmann, 2015). Similarly, Richter et al (2011) examined the effect of context information on emotion recognition within a sample of 48 younger women (mean age 23) and 35 older women (mean age 70) who viewed 48 film clips depicting a female target who talked about an emotional biographical episode and expressed one of three emotions (happiness, sadness, or anger). Half the film were shown without sound (context-poor condition) and half were shown with sound (context-rich condition). Younger women were better at recognizing sadness and anger compared to older women, independent of the condition. The condition did, however, have an effect on age differences in happiness recognition as age-related deficits were only found in the context-poor condition. Thus, suggesting that age differences in emotion recognition are dependent on the context and the emotion (Richter et al, 2011). One of the main shortcomings of both of the above studies is that they employed only female participants.

Although different types of paintings activate different areas in the brain, for example, portraits active the fusiform gyrus, landscapes activate the parahippocampus, and still lifes active the lateral occipital cortex (Chatterjee, 2011), there seems to be little research into the preferences for these different types of paintings. The current research has looked into the

effect of age in preferences for portraits compared to landscapes, in particular, showing that preferences for portraits increases with age. Other research looking at age and art preferences has shown that age has an effect on preferences for paintings in general, and also that younger participants show higher preferences for cubism and renaissance art (Chamorro-Premuzic et al, 2009). Another study specifically looking at age has shown a positive correlation between age and ratings of representational art (Furnham & Walker, 2001). Other research which has not looked at age, but has examined portraits compared to landscapes, has found differences between the two in terms of colour (Polzella et al, 2005). Specifically, 60 students rated 20 paintings of landscapes and portraits of both traditional and modern style. Half the participants viewed the paintings in colour, while the other half viewed them in black and white. Removing the colour from the portraits had a positive effect, showing increased pleasantness and beauty, and reduced tension. However, removing colour from the landscapes reduced their perceived beauty, suggesting that colour in landscapes provided more information such as depth, whereas colour in portraits may be superfluous and distracting (Polzella et al, 2005).

In conclusion, the current study has provided evidence of the effect of age on three factors: colour perception, empathy, and preference for portraits. Specifically showing that colour perception deteriorates with age, levels of empathy (for all types of empathy, including both emotional empathy and cognitive empathy) decrease with age, and preference for portraits increases with age. Overall, this study suggests that age effects both aesthetics and social/emotional cognition. Age is controlled for in all

experiments of empathy and social cognition. In terms of future research, it would be worth finding out whether the effect of age on such factors is apparent within samples of artists, or those who specialise in the use of colour, particularly since previous studies within the thesis have shown creativity (Chapter 5) and colour perception (Chapter 7) to affect levels of empathy. Furthermore, future research could be done to determine whether those who prefer portraits are less empathetic or vice versa. The next study is an exploratory study looking into the creative achievement questionnaire in relation to the different dependent variables previously studied within the current thesis.

10.5 Chapter Highlights

- Cognition appears to follow the pattern of building up and wearing down.
- Performance on the Farnsworth-Munsell 100 Hue Test varies as a U-shape function of age, with children having higher total error scores than adults in their 20s, and performance for older adults deteriorating with age.
- Research suggests age-related gains, longitudinal stability, and cohort decline in empathy and emotional recognition.
- Age has been shown to positively influence preference for painting, and as found to be positively correlated with positive ratings of representational art.
- The aims of the current study were to determine whether there is an effect of age on colour perception, empathy, and preferences for paintings.

- The sample consisted of 42 adult participants.
- Measures included self-reports, a test of colour perception and images of paintings.
- Results revealed that as age increases, colour acuity decreases, empathy levels also decrease as age increases, and preference for portraits over landscapes increases as age increases.
- The current findings provide support for the hypotheses and previous research.
- Future research could find out whether the effect of age on such factors examined within the current study is apparent within samples of artists, or those who specialise in the use of colour.

Chapter 11: Individual Creative Behaviours

11.1 Introduction

The previous chapter (Chapter 10) has looked into the effects of age on colour perception, empathy, and preference for paintings. It was found that as age increases, colour acuity decreases, empathy levels also decrease as age increases, and preference for portraits over landscapes increases as age increases. These findings are important as they show how social cognition and aesthetic preferences change as age increases, thus bringing a greater understanding of the process of aging. The present exploratory study explored the creative achievement questionnaire (CAQ; Appendix 4), looking into the individual creative behaviours in relation to the different dependent variables previously studies within the current thesis. The reason for this was to not miss any important findings which may have otherwise been overlooked.

One potential shortcoming of the creative achievement questionnaire (CAQ; Appendix 4) is that it combines all scores from each individual creative behaviour. Given that this thesis is looking at the wider field of empathy and embodied cognition, for exploratory purposes, it is important to discriminate between different types of creative behaviours. For example, it is not unreasonable to assume that different creative behaviours will have different neuropsychological and neurobiological underpinnings.

The CAQ (Appendix 4) measures level of expertise in various creative behaviours, and not only do experts differ from laypeople in terms of brain activations (as reviewed in Chapter 3), but brain activations also differ

depending on the type of creative behaviour. According to Milton et al (2007), experts in sport compared to laypeople/novices have developed a focused and efficient organisation of task-related neural networks due to extensive practice over a long period of time, unlike novices who have difficulty filtering out irrelevant information. This was found in a sample of expert golfers and novices during a pre-shot routine, as they showed different brain region activations. The brain regions activated in the novices were the posterior cingulate, the amygdala-forebrain complex, and the basal ganglia. Activations in the experts on the other hand, were primarily in the parietal lobule, the dorsal lateral premotor area, and the occipital area (Milton et al, 2007). A study examining expert divers compared to novices shows that the expert divers had increased cortical thickness in the left superior temporal sulcus, the right parahippocampal gyrus and the right orbitofrontal cortex, and years spent training also correlated with the mean cortical thickness of the right parahippocampus gyrus (Wei et al, 2011). Other research has investigated the neural correlates of creative writing in 28 health participants, showing that creative writing activates motor and visual brain areas for handwriting as well as cognitive and linguistic areas (Shah et al, 2013). Therefore, these studies importantly show that different creative behaviours involve and activate different neural areas, and the neural areas which are involved/activated is strongly dependent on the level of expertise within a given field.

Therefore, in this chapter, further analysis was conducted in order to compare whether scoring high or low on *each* individual creative achievement behaviour revealed a significant difference in the scores

obtained on the dependent variables (colour perception, divergent thinking, ToM Faces, ToM Eyes, emotional empathy, emotional and cognitive empathy, and imagination). The creative behaviours asked about in the questionnaire are: (i) visual arts, (ii) music, (iii) dance, (iv) architectural design, (v) creative writing, (vi) humour, (vii) inventions, (viii) scientific discovery, (ix) theatre and film, and (x) culinary arts. A person was classed as high scoring if they were above the mean score and low if they were below the mean score.

11.2 Results

The intention of the present experiment was to provide exploratory analysis into the different creative behaviours from the CAQ (Appendix 4) in relation to all the other dependent variables tested in this thesis, as listed in the table below. The purpose was to investigate whether different creative behaviours are linked to different social cognitive mechanisms. To recap, a person was classed as high scoring if they were above the mean score and low if they were below the mean score. See Table 1 for descriptive statistics.

Table 1: Means and Standard Deviations for each Variable

Variable	***Name of Test***	***Mean***	***SD***	***Range (Actual scores)***	***Range (Possible scores)***
Colour Perception	Farnsworth-Munsell 100 Hue Colour Vision Test (Farnsworth, 1949, 1957)	34.51	23.94	0-98	0->100
Creative Achievement	Creative Achievement Questionnaire (CAQ; Carson et al, 2005)	10.05	8.22	2-36	0->280
Creative Behaviours	Biographical Inventory of Creative Behaviours (BICB; Batey, 2007)	6.95	3.87	1-17	0-34
Divergent Thinking	Alternate Uses Test, Form B Test Booklet (AUT; Christensen et al, 1960)	17.65	6.28	1-33	0-36
Emotional and Cognitive Empathy	Interpersonal Reactivity Index (IRI; Davis, 1983)	71.14	14.50	35-97	0-112
Emotional Empathy	Toronto Empathy Questionnaire (TEQ; Spreng et al, 2009)	47.81	7.66	30-61	0-64
Imagination	Two-factor Imagination Scale (TFIS; Thompson, 2008)	46.38	10.51	28-64	0-66
ToM Eyes	Reading the Mind in the Eyes Test, Revised Version (Baron-Cohen et al, 2001)	26.76	4.28	17-34	0-37
ToM Faces	Faces Test (Baron-Cohen et al, 1997)	18.57	1.24	14-20	0-20

As this is exploratory, the data were submitted to a MANOVA with the seven dependent variables (colour perception, divergent thinking, ToM faces, ToM eyes, emotional empathy, emotional and cognitive empathy, and imagination). See Table 2 for significant values.

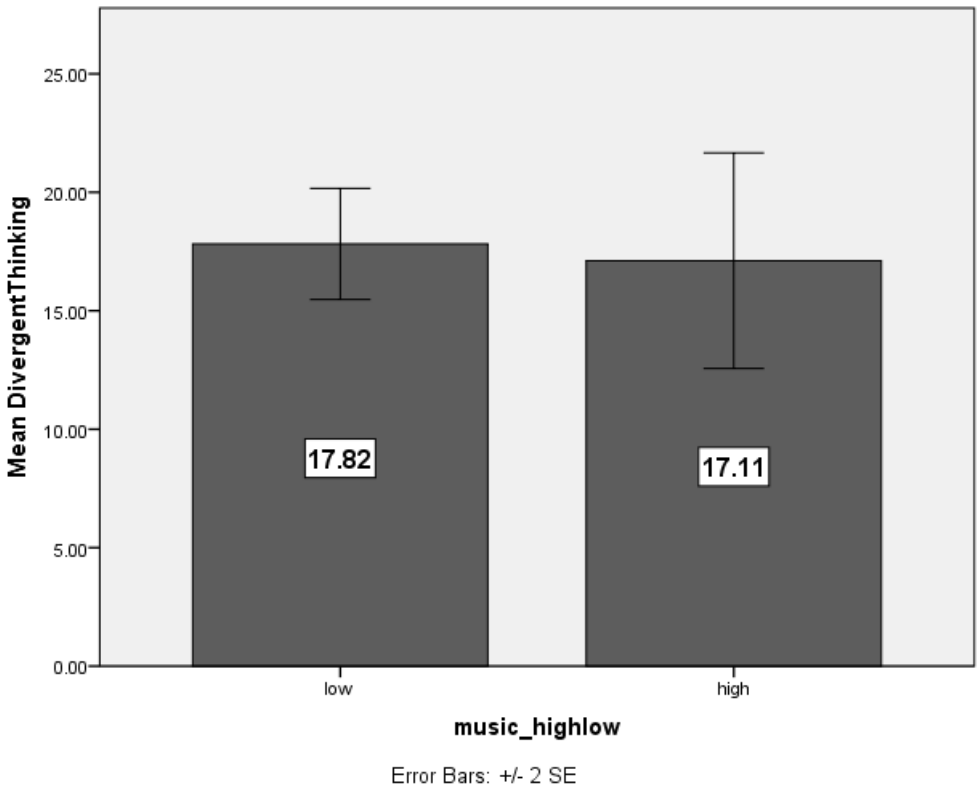
Table 2: Significance Values for Individual Creative Behaviours

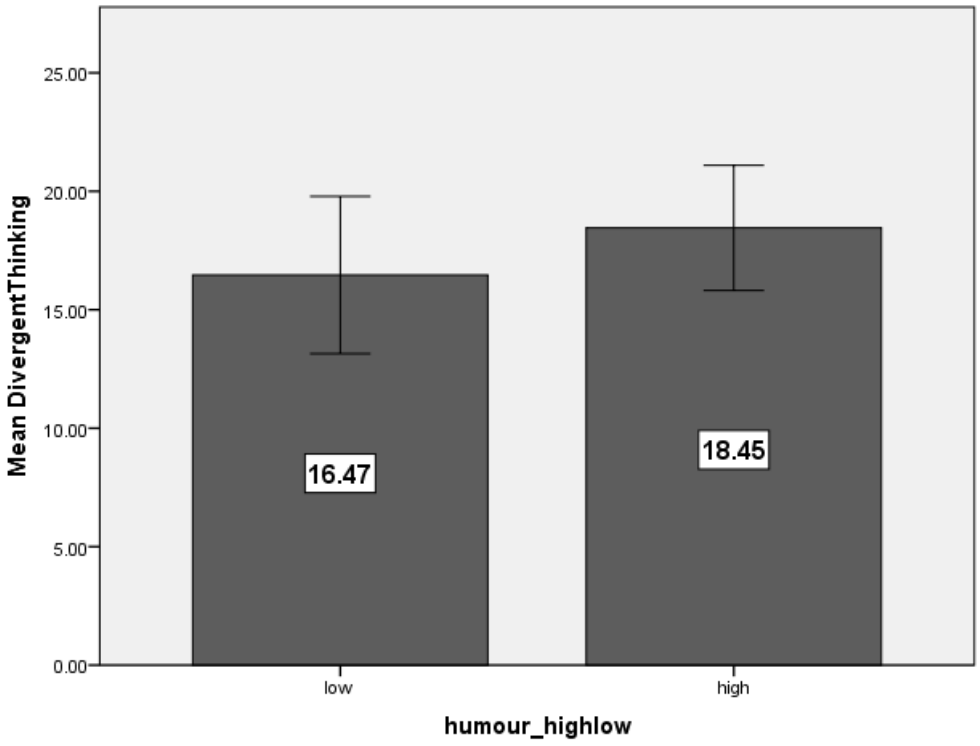
	VS	***M***	***D***	***AD***	***CW***	***H***	***I***	***SD***	***TF***	***CA***
1	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
2	N.S	$p < .05$	N.S	N.S	N.S	$p < .05$	N.S	N.S	N.S	N.S
3	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
4	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
5	N.S	N.S	N.S	$p < .05$	N.S	N.S	N.S	N.S	N.S	N.S
6	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
7	N.S	N.S	N.S	N.S	N.S	N.S	$p < .01$	N.S	N.S	N.S

Key: Visual Arts = ***VS***, Music = ***M***, Dance = ***D***, Architectural Design = ***AD***, Creative Writing = ***CW***, Humour = ***H***, Inventions = ***I***, Scientific Discovery = ***SD***, Theatre and Film = ***TF***, Culinary Arts = ***CA***, Colour Perception = ***1***, Divergent Thinking = ***2***, ToM Faces = ***3***, ToM Eyes = ***4***, Emotional Empathy = ***5***, Emotional and Cognitive Empathy = ***6***, Imagination = ***7***

As shown in Table 2, most of the findings were N.S, however given that there were some significant findings, for those variables that reached significance, participants were split up into high and low achievers – see below for graphical representations of the data in order to investigate these

variables further. As can be seen from the table and the graphs below, those creative behaviours that reached significance were music x divergent thinking, humour x divergent thinking, and architectural design x emotional empathy, all at the < 0.05 significance level. Moreover, inventions x imagination also reached significance, showing a stronger significance level of < 0.01.





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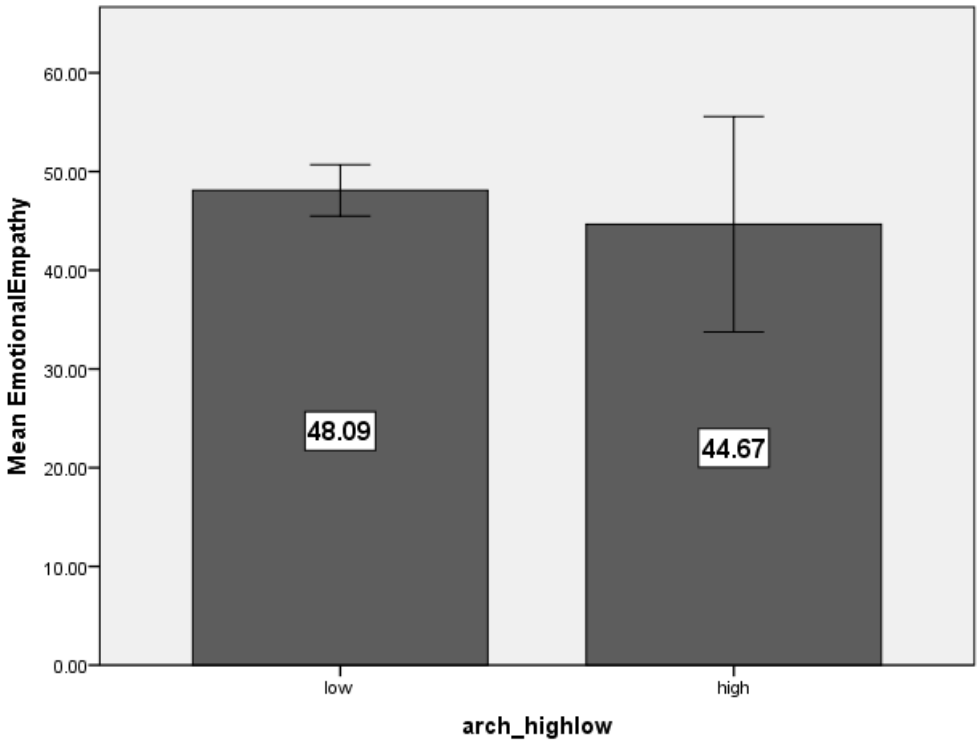

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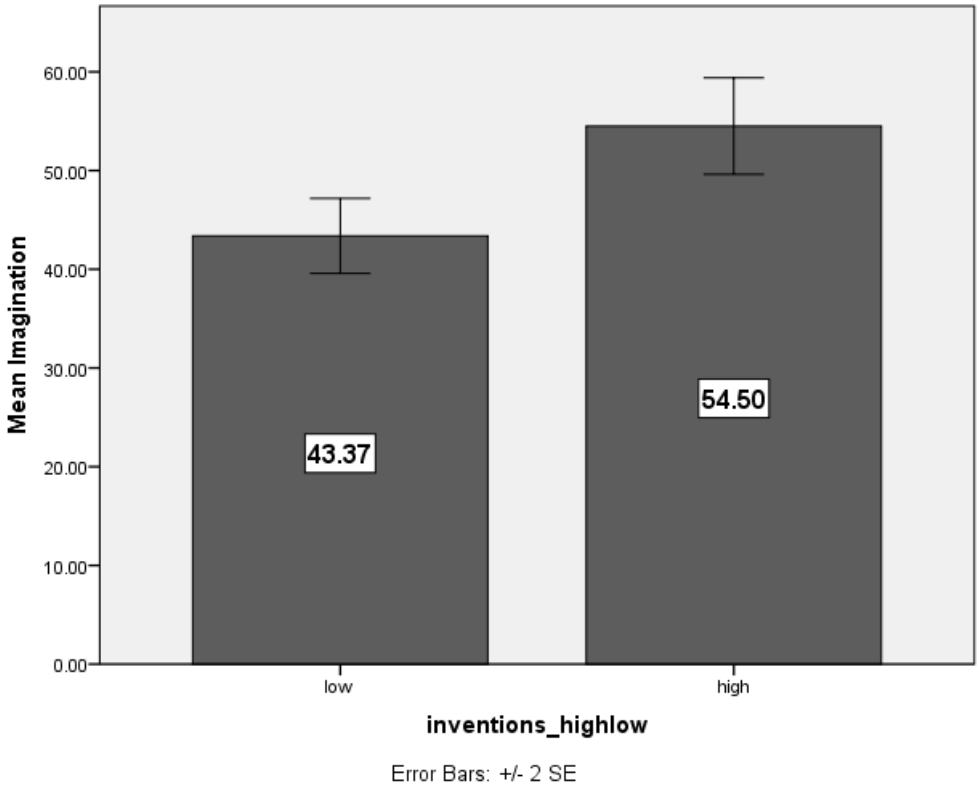

Figure 1: Bar charts displaying the significant differences in mean scores between low and high creative achievement groups on various creativity and empathy variables

11.3 Discussion

Analysis of the individual creative behaviours for the CAQ (Appendix 4) found significant differences in divergent thinking between individuals who scored high in music achievement compared to individuals who scored low in music achievement, showing that those who scored low in music had a higher level of divergent thinking ability. Also for divergent thinking, significant differences were found between individuals who scored high in humour compared to those who scored low in humour, with those scoring high in humour having better divergent thinking ability. Significant

differences were also found in emotional empathy between high and low scorers in architectural design, specifically, those scoring low in architectural design had higher levels of emotional empathy. Furthermore, significant differences were found in imagination between high and low scorers in inventions, showing that those who scored high in inventions had better imagination. To now discuss each finding in turn:

11.3.1 Music

Divergent thinking, a thought process which is used to generate creative ideas through exploring a number of possible solutions, is thought to be a potential predictor of creative problem solving (Runco, 2008). Contrary to previous research, the current finding shows that individuals who scored low in music achievement showed a higher level of divergent thinking ability. Previous research shows the opposite, for example, Gibson et al (2009) conducted two experiments, the first was a behavioural experiment which found enhanced creative thinking in musicians. The second experiment revealed greater bilateral frontal activation during a divergent thinking task, than during a control task, within the same musicians via the use of functional near-infrared spectroscopy (NIRS), suggesting that trained musicians are characterised by enhanced divergent thinking ability (Gibson et al, 2009). Other studies have also demonstrated the advantage of music achievement on divergent thinking ability, and vice versa (Beaty et al, 2013; Benedek et al, 2014). For instance, Beaty et al (2013) investigated 10 male jazz students in relation to cognitive and creative abilities. The participants performed a video-recorded improvisation (a piece of music they had never previously performed) and completed measures of divergent thinking,

working memory, and fluid intelligence. It was found that divergent thinking strongly predicted performance quality (Beaty et al, 2013). Furthermore, Benedek et al (2014) tested 120 students of classical, jazz and folk music in relation to psychometric creativity and personality. The jazz music students showed higher divergent thinking ability compared to the students from other genres, and also showed a higher number of creative activities and achievements in the musical domain (Benedek et al, 2014). This study shows that divergent thinking ability may be dependent on the types or genre of music in which an individual shows talent. Given the CAQ (Appendix 4) was not used for these studies this research cannot be directly compared to the present study. Further research is required, however the result does indicate that the CAQ (Appendix 4) may not be the most useful measure of creative behaviour.

11.3.2 Humour

The current study showed that those who scored high in humour had better divergent thinking ability than those who scored low in humour. This finding concurs with research conducted by Kellner and Benedek (2017), who tested humour production in 151 participants. They were instructed to generate funny punch lines to six caption-removed cartoons. It was found that intelligence and creative potential predict humor production ability independently, and that divergent thinking fluency, as well as creativity and crystallized intelligence, explained unique variance of the funniness of humor productions (Kellner & Benedek, 2017). Humour is not investigated par se in this thesis but investigation into different types of humour, of which there are

many, and its clear role in empathy and theory of mind is certainly worth further investigation.

11.3.3 Architecture

According to the current findings, those who scored low in architecture have higher emotional empathy. There seems to be no previous research into empathy and architecture, and the present finding seems unlikely and unconvincing, particularly since the sample did not focus on architects versus non-architects. Moreover, it is less likely that non-experts generate a high score in the creative achievement of architectural design. Still, again this is worth reporting here as it does question whether the CAQ (Appendix 4) is the best way to measure creative behaviours.

11.3.4 Inventions

The current study found that those who scored high in inventions had better imagination. Out of all the findings, this was shown to have the highest significance level, <0.01. It is evident that in order to invent, you need a good imagination, however, again there seems to be no research on this. Regarding further research, this subset of people would provide to be an interesting group to study in relation to the cognitive neuroscience of imagination/invention processing. It is important to note that this may have been overlooked had the different creative behaviours from the CAQ (Appendix 4) not been split up and investigated separately here.

11.3.5 General Discussion

The main criticism of the CAQ (Appendix 4) in general is that is it better suited to measuring Big-C creativity (eminent or genius level creativity)

rather than little-c creativity (everyday creativity) (Kaufman & Sternberg, 2007), which would be more representative of the general population. The population sample used here did not compare experts and laypeople, instead the sample was taken from the general population, which may not be the best fit for analysing high compared to low scores on the CAQ (Appendix 4), however it is expected that a stronger finding would be seen when using a group of experts in the analysis.

Whilst it is not the aim of this thesis to look at other creative behaviours, in conclusion, this exploratory analysis did reveal a different pattern of results on the dependent variables for some of the different creative behaviours measured with the CAQ (in particular music, humour, inventions and architecture). Therefore combining all results from the CAQ (Appendix 4) may lead to the omission of interesting and important findings. Future research could aim to adapt the questionnaire in a way that will allow robust data to be gathered for each creative behaviour separately. This will help the wider field of creativity, along with specific research into different creative behaviours, to progress.

11.4 Chapter Highlights

- It is important to discriminate between different types of creative behaviours.
- The CAQ measures level of expertise in various creative behaviours.
- Experts differ from laypeople in terms of brain activations.
- Analysis was conducted in order to compare whether scoring high or low on *each* individual creative achievement behaviour revealed a

- significant difference in the scores obtained on the dependent variables.
- The sample consisted of 37 adult participants.
- Measures included self-reports and tests of cognition and perception.
- Results revealed significant differences for music, humour, architecture and inventions.
- Those who scored low in music had a higher level of divergent thinking ability.
- Those scoring high in humour had better divergent thinking ability.
- Those scoring low in architectural design had higher levels of emotional empathy.
- Those who scored high in inventions had better imagination.
- The main criticism of the CAQ in general is that is it better suited to measuring Big-C creativity (eminent or genius level creativity) rather than little-c creativity (everyday creativity).
- Future research could aim to adapt the questionnaire in a way that will allow robust data to be gathered for each creative behaviour separately.

Chapter 12: General Discussion and Conclusion

12.1 Introduction

This thesis has presented a series of experiments that have added knowledge to the field of embodied cognition, which assumes that cognition is related to the physical body and that an individual's understanding of the world is dependent on simulations using neural and bodily systems of action, perception, and emotion (Glenberg et al, 2013). Specifically, the thesis examined creativity (Chapters 5 & 6), perception – particularly colour perception (Chapters 7 & 8) - and sensory processing sensitivity (Chapter 9) and how they link with social cognitive processes such as empathy and ToM. The thesis also looked at the effect of aging – specifically in relation to empathy and colour perception which deteriorate with age, painting preference whether it be those with a social component (e.g. portraits) or not (e.g. landscapes) (Chapter 10) and explored the reliability and usefulness of investigations into individual creative behaviours (Chapter 11) which are usually combined to reveal a single/total score. This final chapter focuses on a discussion of the findings from the experimental chapters and their implications. Furthermore, this chapter will summarise the thesis as a whole, and it will also address the various methodological considerations and provide ideas for possible future research.

12.2 Motivation

Theories of embodiment have become a major conceptual framework for understanding the mind, including the social mind, over recent years (Winkielman et al, 2015). According to theories of embodiment, the

processing of information about flavours, emotional faces, driving directions, social/personality characteristics, as well as social, emotional, moral, and motivational concepts, and many other kinds of information, is influenced, informed by, associated with, and sometimes dependent on perceptual, somatosensory, and motor resources (Winkielman et al, 2015). The finding of mirror neurons, which activate when the individual performs an action and when they observe or hear the same action (Di Pellegrino et al, 1992), provides support for embodiment through embodied simulation. Through embodied simulation, the brain-body system re-uses part of its neural resources to map other people's behaviours (Gallese & Guerra, 2012). For example, the motor system is activated when other people's actions are witnessed (Gallese & Guerra, 2012). Furthermore, when an individual activates other cortical regions they re-use their affective and sensory-motor neural circuits to map the emotional and somatosensory experiences of others, thus allowing a direct access to the world of others (Gallese & Guerra, 2012).

The recently established link between embodiment and aesthetics is only just beginning to build momentum within the domain of the cognitive sciences. Thus, much more research is needed to fully understand the extent of the relationship between the two. The relatively recent proposal made by Freedberg and Gallese (2007), assumes that empathy may be felt through the content and subject matter of art, and also that empathy may be felt through the way in which the artist has creatively used their materials to convey a representation. According to Freedberg and Gallese (2007), embodied simulation may be a crucial factor in allowing the individual to

empathize with others through activating their own internal representations concerning the actions, emotions, or sensations of the bodily states which are being expressed by the other. This is related to the shared manifold hypothesis (Gallese, 2001) which assumes a link between mirror neurons and empathy, as it is through a shared manifold that individuals are able to recognise other human beings, and that it is a mirror matching mechanism which allows others' pains, emotions and sensations to be empathised with and understood.

Thus far, although sparse due to its recent emergence and current surge in popularity, there is evidence of a link between embodiment and aesthetics (Di Dio et al, 2007; Ticini et al, 2014; Tschacher et al, 2012). This has specifically shown a relationship between physiological responses during the perception of artwork and report based aesthetic-emotional experiences of it (Tschacher et al, 2012); motor resonance congruent with the movements portrayed in sculptures (Di Dio et al, 2007); and the influence of action priming on aesthetic appreciation (Ticini et al, 2014). Furthermore, it is apparent that specialising in a particular creative activity enhances mirror neuron activation during the observation of the same creative stimuli (Bangert et al, 2006; Calvo-Merino et al, 2005), however it remains unknown whether creative individuals in general have a stronger overall mirror mechanism, thus being more empathetic in general. Therefore, it was important to investigate the link between level of creativity and level of empathy as there is a lack of research into this. Moreover, the innate trait known as SPS was another important aspect to investigate as SPS, which is characterised by greater sensitivity to social and environmental stimuli

(Acevedo et al, 2014; Jagiellowicz et al, 2016), is also linked to embodiment and includes a measure of aesthetic sensitivity.

The thesis has also focused on colour perception in relation to empathy and ToM as this has not yet been investigated in the literature as far as the researcher is aware. The perceptual stimulus of colour is a ubiquitous human trait (Elliot & Maier, 2014). The purposes of colour are often considered in relation to aesthetics, however the effects of colour on humans has been widely studied and it is evident that colour is imbued with meaning and can profoundly influence an individual's affect, cognition, and behaviour (Elliot & Maier, 2014). Various research into the psychology of colour has demonstrated that colour is related to an individual's feelings and emotions in terms of associations (Clarke & Costall, 2008; Kaya & Epps, 2004; Terwogt & Hoeksma, 1995; Wexner, 1954) and the effects that it has on mood (Hatta et al, 2002; Stone & English, 1998; Stone, 2001; Stone, 2003). Moreover, colour has also been shown to have an impact on physiological reactions, for example red has been shown to cause changes in heart rate, and a room with visible brown posts/beams caused a state that was less calm and more active/aroused compared to an ordinary designed room with plain white walls (Kuller et al, 2009; Tsunetsugu et al, 2005). Other research also shows that a person's feelings and emotions may alter their perception of colour, for example, depression has been shown to impair colour perception/sensitivity and other emotions have been shown to enhance colour discrimination (i.e. red for anger and white/grey for disgust) (Barrick et al, 2002; Fetterman et al, 2011; Sherman et al, 2012). Thus, since there is a strong link between colour and emotion, and as feelings may

alter colour perception, it was important to decipher whether colour perception is related to empathy and ToM, two processes involved in social cognition.

12.3 Main Findings

Overall, in a series of experiments, this thesis has shown that an individual's level of (i) creativity, (ii) colour perception and (iii) SPS influences their embodied and social cognition, specifically, level of empathy and ToM ability. According to the shared manifold hypothesis (Gallese, 2001), this would suggest that those individuals who are more creative, have better colour perception, and are high in SPS, have a stronger mirror mechanism. The results obtained throughout the thesis therefore provide a firm basis for future research. It was then important to investigate this in a cohort with lower empathy levels and lower colour perception. This was looked at via ageing as these two variables decrease with age and the main findings were that (i) colour perception deteriorates with age, (ii) levels of empathy (for all types of empathy, including both emotional empathy and cognitive empathy) decrease with age, and (iii) preference for portraits increases with age. Finally a thorough analysis of the creative achievement questionnaire (CAQ; Appendix 4) was investigated (given that findings remained unclear in a number of the studies used here) and it was found that (i) those who scored low in music had a higher level of divergent thinking ability, (ii) those scoring high in humour also had better divergent thinking ability (iii) individuals scoring low in architectural design had higher levels of emotional empathy, and (vi) those who scored high in inventions had better imagination. For

each experiment within the thesis, as many participants were recruited as possible within the time limits available.

The results of Chapter 5 show that there is a link between creativity and empathy, specifically showing that empathy levels are dependent on an individual's level of creativity. A number of creativity and empathy measures were employed, including self-reported creative achievement, creative behaviours, and a test of creative cognition/divergent thinking, self-reported emotional empathy, and emotional & cognitive empathy taken as a whole. There was a significant effect of creative behaviours on emotional empathy, as well as the emotional & cognitive empathy subscales: perspective taking and empathic concern. Furthermore, divergent thinking was shown to have a significant effect on the emotional & cognitive empathy subscales: perspective taking and personal distress. These particular findings suggest that individuals who are more creative exhibit greater levels of empathy for certain types of creativity and empathy, providing some support for previous research (Kalliopuska, 1989; Kalliopuska, 1991; Rabinowitch et al, 2013) and the current hypothesis. This was the first study, as far as the researcher is aware, to examine different types of creativity in relation to different types of empathy within an adult sample of the general population.

Similarly, Chapter 6 examined different types of creativity in relation to ToM, a form of cognitive empathy. Two different measures of ToM were employed, specifically ToM Faces (Appendix 8) and ToM Eyes (Appendix 7), both vary in difficulty as the Faces Test shows images of the full face, whereas the Eyes Test merely shows images of the eye region (See Appendix 7 and Appendix 8). It was shown that there was a significant effect

of creative behaviours on ToM Faces and ToM Eyes, and a significant effect of divergent thinking on ToM Faces (but not ToM Eyes). Again, this was the first study, as far as the researcher is aware, to examine different types of creativity in relation to ToM. There was no effect of creative achievement on any of the empathy and ToM measures in either study (Chapter 5 or Chapter 6). Perhaps this is because it was not the best measure for a general population sample, and would therefore be better suited for an expert sample, particularly as it seems to be a measure of Pro-c and Big-C creativity (expert and genius level creativity) (Beghetto & Kaufman, 2007; Kaufman & Beghetto, 2009). Results from these two chapters suggests that the measure of creative behaviours (BICB; Batey, 2007; Appendix 1) and the test of divergent thinking (AUT; Guilford et al, 1960; Appendix 6), are better tools for measuring level of creativity with the general population, as they both measure little-c creativity (everyday creativity).

Chapters 7 and 8 looked into colour perception as a predictor of empathy and ToM respectively, as colour serves as an aesthetic and is involved in many aspects of creativity. This was particularly important since no research, as far as the researcher is aware, has ever linked colour perception with empathy/ToM before. The closest research to the current study suggests that the perception of colour may be effected by emotion, for specific colours and emotions, particularly those that are associated with one another (Fetterman et al, 2011; Sherman et al, 2012; Ziems & Christman, 1998). Such findings are similar to the findings of the current experiments as they suggest that emotion and emotional sensitivity is related to colour and colour perceptual sensitivity. The study of Chapter 7 revealed colour acuity

to be a significant predictor of empathy, for emotional empathy and for emotional & cognitive empathy taken as a whole, specifically showing that those with better colour perception have higher levels of empathy. Exploratory analysis into the emotional & cognitive empathy subscales showed colour acuity to have a significant effect on both cognitive subscales (perspective taking and fantasy), but none of the empathy subscales (empathetic concern and personal distress), which is interesting because this particular finding may suggest that dopamine is an important factor to consider, as dopamine is related to both colour perception (Banaschewski et al, 2006; Colzato et al, 2014; Hulka et al, 2013; Tannock et al., 2006) and cognitive empathy (Lackner et al, 2010; Uzefovsky et al, 2014). Both the TEQ (Appendix 9) and IRI (Appendix 5) have previously been shown to demonstrate good reliability and validity (Christopher et al, 1993; Davis & Franzoi, 1991; Spreng et al, 2009).

The study of Chapter 8 looked specifically at ToM mechanisms and showed colour acuity to be a significant predictor of ToM Eyes, demonstrating that an individual with better colour perception is more likely to have better ToM ability, which is a novel and important finding for the field of social cognition. However, although a positive relationship was also found for ToM Faces, it did not reach significance. The differences found between these two types of ToM may be because the ToM Eyes Test (Appendix 7) was devised in order to generate a more sensitive measure of adult social intelligence which is able to detect meaningful individual differences, however the original (ToM Faces Test; Appendix 8) was merely designed as a measure of extreme performances (Baron-Cohen et al, 2001).

Chapter 9 investigated SPS and empathy, ToM and colour perception. It was important to focus on some of the positive aspects (increased empathy, ToM and better colour perception) of SPS as previous research has tended to focus on its negative aspects (stress and ill health, anxiety, depression, social phobia, avoidant personality disorder, and social introversion and emotionality) (Aron & Aron, 1997; Benham, 2006; Liss et al, 2005; Meyer & Carver, 2000; Neal et al, 2002). In this experiment, it was found that there is a significant effect of a person's SPS on emotional & cognitive empathy, emotional empathy, and ToM, showing that individuals high in SPS have higher empathy and ToM ability. Exploratory analysis into the emotional & cognitive empathy subscales revealed that those high in SPS have significantly higher empathy levels for all subscales (perspective taking, empathic concern, and personal distress) except the fantasy subscale. This may be because the fantasy subscale may be a better assessment of imagination as opposed to the theoretically driven notions of empathy (Baron-Cohen & Wheelwright, 2004; Spreng et al, 2009). Imagination itself is an interesting area to study in future research. The study of Chapter 9 also shows that individuals with more acute colour perception score significantly higher in SPS, providing a good link between all results. Exploratory analysis into the HSPS subscales (ease of excitation - being mentally overwhelmed by both internal (pain, hunger, taste) and external (light, noise) stimuli, aesthetic sensitivity - awareness and appreciation of beauty, and low sensory threshold - unpleasant arousal by external stimuli such as bright lights and loud noises) revealed a significant difference in excitation and aesthetic sensitivity based on colour acuity indicating that

individuals with more acute colour perception score higher on these subscales, however, no significant difference in the low sensory threshold subscale was found. Colour acuity was also found to be a significant predictor of ToM Eyes, replicating the results of Experiment 4 (Chapter 8), and highlighting the strength and robust nature of this finding.

Chapter 10 found that age has an effect on colour perception, empathy and preference for paintings and whether the paintings had a social component (portraits) or not. It was important to look into the effects of age as previous research suggests that there are age related declines in colour perception (Kinnear & Sahraie, 2002; Roy et al, 1991; Verriest et al, 1982) and in empathy/emotion recognition (in cohort designs) (Grühn et al, 2008; Phillips et al, 2002; Ruffman et al, 2008; Schieman & Van Gundy, 2000). Firstly, within the current research, age was shown to have an effect on colour perception, specifically showing that as age increases, colour acuity decreases, indicating that younger adults have better colour perception than older adults which is comparable to the literature (Kinnear & Sahraie, 2002; Roy et al, 1991; Verriest et al, 1982). Secondly, it was found that age has an effect on empathy (for emotional empathy and emotional & cognitive empathy as a whole) showing that as age increases, empathy levels decrease. Research on empathy and emotional recognition in cohort designs supports this (Grühn et al, 2008; Phillips et al, 2002; Ruffman et al, 2008; Schieman & Van Gundy, 2000). This analysis shows that this is also the case for all of the emotional & cognitive empathy subscales (perspective taking, fantasy, empathic concern, and personal distress). Lastly, age was shown to have an effect on preference for paintings, indicating that

preference for portraits over landscapes increases as age increases, thus older adults prefer portraits compared to landscapes. Whilst Freedberg and Gallese (2007) assume that empathy may be felt through the content and subject matter of art, it was of interest to see if there was a stronger preference in particular for stimuli that had a social component (portraits) v non-social (landscapes). This showed that as colour perception and empathy levels decreased (with age) preference for social stimuli increased. An interesting finding, further study is warranted.

The last experimental chapter, Chapter 11, focused on examining the individual creative behaviours through the CAQ (Appendix 4) in relation to each variable studied within the thesis (including colour perception, divergent thinking, ToM Faces, ToM Eyes, emotional empathy, emotional & cognitive empathy, and imagination). Chapter 11 was therefore more of an exploratory chapter looking into the wider field of empathy and embodied cognition through examining the creative behaviours individually. These include: (i) visual arts, (ii) music, (iii) dance, (iv) architectural design, (v) creative writing, (vi) humour, (vii) inventions, (viii) scientific discovery, (ix) theatre and film, and (x) culinary arts. Significant findings were revealed for music, humour, inventions and architecture. Specifically, it was found that those scoring low in music had higher levels of divergent thinking ability, those scoring high in humour also had better divergent thinking ability. Furthermore, individuals scoring low in architectural design had higher levels of emotional empathy, and those who scored high in inventions had better imagination. Given these mixed findings and the lack of significance in some of the experiments of this thesis using this particular questionnaire, it calls

into question the efficacy of using this exact questionnaire for this type of research, especially when quite often the score on the questionnaire is totalled (Carson et al, 2005). Although the sample of participants was from the general population within this study, and all the studies throughout the thesis, the CAQ (Appendix 4) may be a better measure of Big-C creativity (eminent or genius level creativity) rather than little-c creativity (everyday creativity), thus it is expected that the results obtained may differ if from an expert sample, which is worthy of further study. Still it is important to investigate the usefulness of this tool for this field of research.

12.4 Future Work

The findings of Chapter 5 and Chapter 6 which suggest a link between creativity and empathy, and creativity and ToM, should be further investigated in a sample of experts as the current experiments within the thesis only focused on a general population sample. Previous research suggests that those who are more creative, i.e. partake in a particular creative subject, such as music or dance, have higher empathy scores than those who do not (Kalliopuska, 1989; Kalliopuska, 1991; Rabinowitch et al, 2013). However, these studies only utilised samples of children. It would therefore be worthwhile examining whether similar results would be obtained in an adult sample. Moreover, it is suggested that the mirror mechanism learns through experience (Gallese, 2010), and research supports this showing that the same brain regions activated more strongly whilst watching a particular creative act if the participant was an expert in the same creative activity as opposed to laypersons (Bangert et al, 2006; Calvo-Merino et al, 2005). Thus, it would be worth examining whether adult creative experts (in

various fields of creative expertise) have higher levels of empathy and better ToM ability than laypeople.

It is clear from the findings of Chapters 5 and 6 that creativity should be encouraged (i.e. in schools, prisons/rehabilitation, and everyday life) due to its benefits regarding social cognition, as skills such as empathy and ToM are important in daily interactions, especially in relation to co-operation and sociocultural learning. Deficits in such skills has been shown to be associated with various pathologies such as sociopathy, autism spectrum disorders, and nonverbal learning disorders (Goldstein & Winner, 2012). However, with some disorders, specifically frontotemporal lobar degeneration, patients sometimes develop a new preoccupation with art, greater attention to visual stimuli, and increased visual creativity (liu et al, 2009).

From the findings that colour perception is a significant predictor of empathy (Chapter 7), and colour perception is a significant predictor of ToM (Chapter 8), it is clear that much more research into the association between colour perception and social cognition is warranted, especially as these findings are novel and are therefore in their infancy. Moreover, since dopamine is implicated in both colour perception (Banaschewski et al, 2006; Colzato et al, 2014; Hulka et al, 2013; Tannock et al., 2006) and empathy, particularly cognitive empathy (Lackner et al, 2010; Uzefovsky et al, 2014), further research into a link between the two in relation to this neurotransmitter is needed. Specifically, it is important for future research to discriminate between the colour confusion axes: protan (red), deutan (green), and tritan (blue) (Pache et al, 2003), as the research findings

relating dopamine to colour perception suggests that the link pertains to the blue-yellow colour axis, and is due to dopaminergic deficiencies in the retina. Therefore, it would be interesting to discover whether the same axis of confusion (blue-yellow) is associated with empathy and ToM. Importantly, the blue-yellow colour perception problems have been found in various disorders including attention deficit/hyperactivity disorder (ADHD), Tourette syndrome, Parkinson's disease, and Huntington's disease (Banaschewski et al, 2006).

Chapter 9 shows SPS to have a significant effect on empathy and ToM, indicating that highly sensitive individuals have higher levels of empathy and better ToM ability. This finding is of importance because it shows SPS to have some positive and beneficial outcomes (i.e. enhanced empathy and ToM), whereas much previous research into SPS has tended to focus on its negative associations such as stress and ill health (Benham, 2006), anxiety (Liss et al, 2005; Neal et al, 2002), depression (Liss et al, 2005), social phobia (Neal et al, 2002), avoidant personality disorder (Meyer & Carver, 2000), social introversion and emotionality (Aron & Aron, 1997), and autism (Kern et al, 2006). However, research which has looked into the HSPS subscales (ease of excitation, aesthetic sensitivity, and low sensory threshold) has found aesthetic sensitivity to be related to some positive/beneficial outcomes, including well-being, positive affect and openness to experience (Sobocko & Zelenski, 2015), conscientiousness (Ahadi & Basharpoor, 2010), and greater attention to detail and good communication (Liss et al, 2008). Thus, future research into the more positive aspects of SPS in general (or as a whole) is need in order to balance

the literature, as being a highly sensitive person may not necessarily be negative, as could potentially be suggested by the current results. These findings may also explain why autism is linked to sensory processing disorder (Kern et al, 2006). Sensory processing disorder is where individuals find it difficult to regulate responses to sensations and specific stimuli, suggesting poor sensory integration in the central nervous system, and this can affect one or multiple sensory systems, such as vision, auditory, gustatory (taste), olfactory (smell), tactile (touch), proprioceptive (joint position sense), and vestibular (balance and movement) (Pfeiffer et al, 2011).

In addition, another important finding from Chapter 9, shows that there is a significant link between colour acuity on SPS, and the subscales excitation and aesthetic sensitivity (but not low sensory threshold) i.e. those with better colour perception scored higher in SPS in general, as well as the afore mentioned subscales. This suggests that certain perceptual abilities may affect various types of sensitivities, which warrants further study. Specifically, other forms of perception, such as visual perception and smell, touch, and taste perception for example, should be investigated in relation to SPS and its subscales in order to find out which types of perception are most affected by SPS. Furthermore, the results of Chapter 9 should be replicated using physiological measurements to investigate whether the results would be supported by such measurements.

From Chapter 10 it is clear that age affects both aesthetics and social/emotional cognition. In particular, Chapter 10 shows age to affect colour perception, empathy, and preference for portraits, indicating that

colour perception deteriorates with age, levels of empathy decrease with age, and preference for portraits increases with age. These findings may also be connected to ToM and the Eyes and Faces test as portraits may resemble such tests, and previous studies have also shown colour perception to be a predictor of ToM (Chapter 8). However, unlike ToM measures, the preferences for portraits was based on how much the participant liked the portrait rather than whether they were able to correctly detect the emotion expressed in the image. From this, future research could look into the effect of age on the variables colour perception, empathy, and preference for portraits in specialised samples such as artists and those who specialise in the use of colour, as chapters within the current thesis have shown creativity (Chapter 5) and colour perception (Chapter 7) to have an effect levels of empathy, which has been shown to be affected by age (Chapter 10). Moreover, more research should be carried out in relation to the difference between preferences for portraits and preferences for landscapes to determine why this preference is being seen, what this 'marker' is actually showing and how it relates to social cognitive neuroscience mechanisms. Such research would be beneficial in the domains of aesthetics and embodied cognition.

Although Chapter 11 found some interesting findings in regards to the individual creative behaviours and the other variables studied within the thesis, it is clear that the CAQ (Appendix 4) is a better measure of Big-C creativity (eminent or genius level creativity), therefore future research would benefit from studying experts and laypeople in relation to the other variables in order to distinguish between the two, rather than focusing on high and low

scorers of creativity in the general population. On the other hand, the CAQ (Appendix 4) could benefit from being adapted to fit a general population sample. The CAQ (Appendix 4) could also be adapted to allow more robust data to be gathered for each creative behaviour separately. This would be advantageous to the wider field of creativity, and would allow specific research into each individual creative behaviour to progress further. Future studies could develop a more appropriate questionnaire to study social cognition, and although this questionnaire is often used in social cognitive experiments (Jung et al, 2010; Kaufman et al, 2016; Silvia et al, 2009; Silvia et al, 2011; Zabelina et al, 2010) this chapter questions its suitability, especially for experiments testing the general population.

12.5 Evaluation of Measures and Limitations

When considering the reliability and validity of the specific measures being utilized within the thesis, the CAQ (Carson et al, 2005; Appendix 4) measuring creative accomplishments within 10 different domains, has not rendered itself open to the traditional analyses of internal consistency. The reason being, each item within each of the domains does not carry the same weight, thus being independent (Silvia et al, 2012). For this reason, the estimation of internal consistency for the 10 domain scores is more informative than the estimation of internal consistency for each of the particular domains (Silvia et al, 2012). Thus, as a whole, the CAQ (Appendix 4) has been shown to contain strong internal reliability (a = .96) (Carson et al, 2005). Moreover, the CAQ (Appendix 4) has been widely used and research has provided evidence of its validity (Silvia et al, 2012). For example, various studies have shown that openness to experience is a strong

predictor of CAQ scores (Hirsh & Peterson, 2008; Silvia et al, 2009). CAQ scores have also been shown to correlate with the scores obtained from the Creative Behavior Inventory (Dollinger, 2003), as well as correlating with scores from divergent thinking tests (Silvia & Kimbrel, 2010). Similarly, the BICB (Batey, 2007) has been shown to be both reliable (Batey & Furnham, 2008; Batey et al, 2010) and valid, correlating with openness to experience and divergent thinking fluency (Furnham et al., 2008; Batey et al, 2010). Furthermore, Guilford's Alternative Uses Test (1967) (Appendix 6) which is a measure of divergent thinking ability was also used within the thesis. Research has provided neurological evidence demonstrating that divergent thinking abilities are enhanced within creative individuals, thus providing support for a relationship between divergent thinking and creativity (Gibson et al, 2009). However, it is recognised that divergent thinking tests are not completely representative of creativity in general; they are merely an estimate or potential predictor of creative problem solving and creative cognition/processing (Piffer, 2012; Runco, 2008). Hence, overall, experiments within the thesis have measured creative achievement, creative behaviour and creative cognition, with the aim of generating a more complete overview of the participants' level of creativity.

Within the experiments in this thesis, empathy was measured using various self-reported methods, namely the IRI (Davis, 1983; Appendix 5) and the TEQ (Spreng et al, 2009; Appendix 9). The TEQ (Appendix 9) is a fairly recently developed questionnaire which was designed to measure empathy primarily as an emotional process (Spreng et al, 2009). According to Spreng et al (2009), the TEQ (Appendix 9) is a brief, reliable and valid measure of

empathy; specifically showing strong convergent validity and positively correlating with behavioural measures of social decoding and self-reported measures of empathy. The TEQ (Appendix 9) also correlated (negatively) with a measure of autism symptomatology and demonstrated high test-retest reliability and good internal consistency within three studies (Spreng et al, 2009). A strength of the IRI (Appendix 5) is that it measures both emotional and cognitive empathy, containing four subscales: perspective taking (cognitive), fantasy (cognitive), empathetic concern (affective), and personal distress (affective) (Davis, 1983) which was important for the studies of this thesis so all empathy levels could be assessed, analysed and critiqued. Its initial validation revealed internal consistency (Davis, 1994) and further studies have also confirmed good internal consistency and predictive and convergent validity (Christopher et al, 1993; Davis & Franzoi, 1991). However, it has been criticised by some as not being an accurate measure of empathy (Alterman et al, 2003; Baron-Cohen & Wheelwright, 2004; Cliffordson, 2001; Spreng et al, 2009). For example, the fantasy and personal distress subscales may be a better assessment of imagination as opposed to the theoretically driven notions of empathy (Baron-Cohen & Wheelwright, 2004; Spreng et al, 2009), and the personal distress subscale also seems to measure discomfort, anxiety, and loss of control in negative situations (Spreng et al, 2009). Perhaps this is why Chapters 5 and 7 generated some non-significant findings concerning the exploratory analysis into the IRI subscales. Furthermore, although personal distress may be an important factor to consider, it is not a representative form of empathy itself (Lawrence et al, 2004), thus failing to measure the primary concept of

empathy (Cliffordson, 2001). Within the IRI (Appendix 5), the empathetic concern and perspective taking subscales may be the most accurate components for measuring the concept of empathy (Alterman et al, 2003). Future research that is similar to the present studies is needed using physiological measures of empathy and brain imaging techniques to support the current findings.

Social cognition has been examined through the use of two perception tests, specifically measuring social sensitivity through theory of mind. Namely, the reading the mind in the Eyes Test (ToM Eyes), revised version (Baron-Cohen et al, 2001; Appendix 7) and the Faces Test (ToM Faces)(Baron-Cohen et al, 1997; Appendix 8). The Eyes Test depicts images of different emotional states showing the eye region only; it was devised in order to generate a more sensitive measure of adult social intelligence that can detect meaningful individual differences, whereas the original was merely a measure of extreme performances (Baron-Cohen et al, 2001). It has been validated through showing that adults with Asperger's syndrome and high-functioning autism exhibit a significant impairment on this specific test, but not on a gender recognition control test (Baron-Cohen et al, 2001). In addition, an fMRI study has revealed that the amygdala is active in the normal brain, and not active in the autistic brain, whilst adults were engaged in the Eyes Test (Baron-Cohen et al, 1999). The Faces Test is a similar measure of theory of mind which depicts images of the full face expressing both basic and complex mental states (Baron-Cohen et al, 1997). Again, this test has been shown to be valid, demonstrating that control adult participants interpret mental states in the full face fairly consistently and

adults with autism and Asperger's syndrome could detect basic mental states (happy, sad, angry, afraid), but their performance was impaired when detecting complex mental states (scheme, admire, interest, thoughtfulness) within the full face (Baron-Cohen et al, 1997).

The measures used were all investigator-administered. An advantage of this is that questions could be clarified by the investigator if required, and the presence of the investigator often encourages participants to respond to every question (Mitchell & Jolley, 2012). On the other hand, the presence of an investigator may have reduced perceived anonymity, and hence, participants may have been less open and honest with their responses, thus increasing social desirability and impression management whereby the participants try to portray themselves in the best possible way (Langdridge & Hagger-Johnson, 2009; Mitchell & Jolley, 2012), however this remained consistent for all participants. The tests of perception aimed to decipher how participants process and interpret information, thus determining their innate intelligence and intellectual functioning based on specific perceptual qualities (i.e. social cognition and colour discrimination in the research). With both questionnaires and tests of perception, participants may have displayed boredom effects and participant fatigue, however, where participants may have tried to portray themselves in the best possible way through questionnaires, this was not possible within the tests of perception (Langdridge & Hagger-Johnson, 2009).

12.6 Implications of the Thesis

The results presented within this thesis are important for the fields of embodied cognition, Neuroaesthetics and creativity research. They highlight how embodied cognition and its relationship with empathy/ToM is an important aspect to consider in relation to creativity, colour perception, and aesthetics. Findings from this thesis have revealed that there is a link between creativity and empathy and creativity and ToM. While the link between creativity and empathy has already been shown (Carlozzi et al, 1995; Kalliopuska, 1989; Kalliopuska, 1991; Rabinowitch et al, 2013), an in-depth and thorough exploration into the different types of creativity and the different types of empathy had not been provided until now, and this is the first experiment, as far as the researcher is aware, to provide a link between creativity and ToM. If those who are more creative are also more empathetic and have better ToM ability, as this thesis suggests, then it is clear that creativity should be encouraged in order to enhance social/emotional cognition, which would be beneficial to society in general. Creativity could be used in systems such as education/schools, prisons, and mental health (particularly in conditions such as psychopathy which involves low levels of empathy). Concerning the research aims, these findings may imply that creative individuals do have a stronger mirror mechanism than less creative individuals, however more research is needed to confirm this. For example, brain imaging studies into creativity and empathy/ToM should be conducted in the future. Mirror neuron activity could be investigated through analysis of fMRI, MEG, and EEG, particularly mu frequency band oscillations recorded with scalp electrodes over the sensorimotor cortex (Ulloa & Pineda, 2007).

The mu rhythm is an 8-13 Hz oscillation generated in the sensorimotor cortex which reaches maximal amplitude when individuals are at rest, and when they move, imagine movements, or observe movements, mu amplitudes are reduced as neurons in this area fire asynchronously. Frontal mirror neuron activity has been linked to this mu rhythm suppression (Ulloa & Pineda, 2007).

The important and novel findings that colour perception is a predictor empathy, and also that colour perception is a predictor of ToM, suggests that dopamine may be a factor to consider for future research as it is implicated in both colour perception (Banaschewski et al, 2006; Colzato et al, 2014; Hulka et al, 2013; Tannock et al., 2006) and cognitive empathy (Lackner et al, 2010; Uzefovsky et al, 2014). These findings may be important for autism research as individuals with autism have impaired ToM, and find it difficult to understand the complex mental states of others' goals and intentions (Baron-Cohen et al, 1985; Leslie & Thaiss, 1992; Sodian & Frith, 1992), and also perform less well than controls in colour discrimination tasks, indicating impaired colour perception (Cranwell et al, 2015; Franklin et al, 2008; Franklin et al, 2010; Hurlbert et al, 2011). It is thought that one way to improve colour perception is by practicing colour matching, which involves choosing a particular colour and using paints or pencil crayons to make the exact same colour though mixing and blending colours together.

The findings concerning SPS, showing that highly sensitive individuals have higher levels of empathy and better ToM ability, has important implications for the field of social cognition. High SPS can be beneficial in various contexts, and it is important not to just focus on the negative aspects

of SPS, as much of the previous literature has done (Aron & Aron, 1997; Benham, 2006; Liss et al, 2005; Meyer & Carver, 2000; Neal et al, 2002). It seems that there is much more to be learned about SPS, particularly concerning its beneficial outcomes. One particular study that supports the current finding has found a link between empathy and SPS via means of fMRI (Acevedo et al, 2014). The experiment consisted of participants viewing images of either their romantic partners or strangers displaying positive (happy) or negative (sad) emotions through their facial expressions. A year later the experiment was replicated with an added facial expression (neutral). Brain activations were found in regions concerned with awareness, integration of sensory information, empathy (including a region of the mirror neuron system – the inferior frontal gyrus), and action planning in individuals scoring higher in SPS. It was also found that activations were stronger in response to the positive emotions, and when the image was of the participant's romantic partner (Acevedo et al, 2014). In addition, research has shown SPS to be linked to serotonin (Licht et al, 2011) and dopamine (Chen et al, 2011) indicating that SPS is involved in social cognition, and this is interesting since dopamine is implicated in cognitive empathy (Lackner et al, 2010; Uzefovsky et al, 2014) and colour perception (Banaschewski et al, 2006; Colzato et al, 2014; Hulka et al, 2013; Tannock et al., 2006) also. Especially as colour perception is shown to have an effect on SPS within the current thesis (Chapter 9) (also a novel finding). Such findings may have important implications regarding clinical disorders such as autism, Parkinson's disease, schizophrenia, and ADHD as dopamine is strongly implicated in these disorders (Banaschewski et al, 2006; Colzato et al, 2014;

Hulka et al, 2013; Lackner et al, 2010; Tannock et al., 2006; Uzefovsky et al, 2014).

Age was found to affect colour perception, empathy, and preference for portraits. Both colour perception and empathy decreased with age and preference for portraits increased with age. It is interesting that with age, empathy decreases yet preferences for portraits increases, i.e. as people get older they become less empathetic, but they tend to prefer portrait paintings more when compared to landscape paintings, which is a novel and interesting finding. One explanation for this is that as individuals get older they prefer portraits more because they feel less emotional arousal towards them, and therefore do not become too emotionally stimulated by the images, and those who are more empathetic (younger adults) may feel more relaxed when viewing the landscapes and therefore prefer portraits less. Thus, future studies could use questionnaires measuring participants' arousal levels, as well as physiological measurements, whilst viewing portrait and landscape paintings to test whether these scores correlate with empathy measures.

12.7 Thesis Conclusion

This thesis has aimed to fill an important gap in the literature concerning embodiment and aesthetics. This thesis has investigate the link between embodied cognition and aesthetic experiences by focusing on creativity, colour perception, and SPS in relation to empathy and ToM mechanisms. Experiments within the present thesis have looked further into the link between creativity and empathy by focusing on different types of

creativity in relation to the different types of empathy, as well as ToM (a form of cognitive empathy) within an adult sample from the general population and found that there is a link between creativity and empathy and creativity and ToM. An in-depth study into the link between creativity and empathy (and ToM) has never been done before, as far as the researcher is aware. Colour perception/colour acuity as a predictor of empathy, and as a predictor of ToM, was also examined and the results showed that colour acuity is a predictor of empathy and ToM. As far as the researcher is aware, no other literature has either studied, or even hinted at a link between the two before making this an exciting finding for the field of social cognition and its relationship with perception and cognition. Furthermore, in order to balance the literature, it was important to focus on some of the positive aspects of SPS. Thus, SPS in relation to empathy and ToM was examined. As was the effect of colour perception on SPS, which is also novel. Results showed that highly sensitive individuals have higher empathy levels/ToM ability, and that there is a significant effect of colour acuity on SPS. The thesis has also looked into the effect of age on colour perception, empathy/ToM, and preference for paintings, as well as the effects of different types of creative behaviours, and the findings were that colour perception deteriorates with age, levels of empathy decrease with age, and preference for portraits increases with age. Overall, the thesis raises questions concerning the way in which individuals interact with, and understand, the external world's stimuli and how this may be affected by their level of sensitivity towards it.

The thesis encompasses a range of subject areas, including cognitive psychology, neuropsychology, Neuroaesthetics, and social psychology, as

aspects such as embodied cognition, empathy, sensation, perception, and social cognition have been examined. Many of the areas which this thesis has covered are at a nascent stage of development, particularly the study of creativity and the arts, and embodied cognition. Moreover, the findings regarding colour perception are especially novel and innovative. The research has implications for systems such as education/schools, prisons, and mental health, as well as having implications for clinical conditions such as autism, Parkinson's disease, schizophrenia, and attention deficit/hyperactivity disorder.

This thesis has generated novel findings which are worthy of future considerations. Much more research into the areas concerning this thesis is needed in order to generate a more holistic overview of the current findings. Particularly, more brain imaging and physiological research is warranted. This will help the wider fields of embodied cognition and creativity/aesthetics, and Neuroaesthetics to progress.

To summarise, this thesis has provided a number of novel experiments which have generated further knowledge into the fields of creativity, aesthetics and embodiment. Such research will aid the development of future studies within these areas, which will hopefully bring a greater insight into some clinical conditions. From this thesis it is evident that both colour and creativity are important aspects to consider in relation to empathy and social cognition, and activities involving these should be encouraged.

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Appendix 1: Biographical Inventory of Creative Behaviours

Please answer as truthfully as you can. Place a cross (X) next to the activities you have been actively involved in.

In the past 12 months have you…

1 Written a short story

2 Written a novel

3 Organized an event, show, performance or activity

4 Produced a TV/Play script

5 Designed and produced a textile product (e.g. made an item of clothing or household object)

6 Redesigned and redecorated a bedroom, kitchen, personal space, etc.,

7 Invented and made a product that can be used

8 Drawn a cartoon

9 Started a club, association or group

10 Produced a picture, i.e. NOT a doodle (using paint, pencils, charcoal, acrylic, etc.,)

11 Had an article published

12 Formed a sculpture using any suitable materials

13 Recognised where an accepted scientific theory/approach does not explain what it purports to

14 Produced your own food recipes

15 Produced a short film

16 Produced your own website

17 Produced a theory to explain a phenomenon

18 Invented a game or other form of entertainment

19 Selected to lead/manage others

20 Made someone a present

21 Composed a poem

22 Adapted an item and used it in a way that it was not designed to be, in what you consider to be an ingenious way

23 Published research

24 Choreographed a dance

25 Designed and planted a garden

26 Produced a portfolio of photographs (NOT photographs of a holiday, party, etc.,)

27 Acted in a dramatic production

28 Delivered a speech

29 Mentored/Coached someone else to improve their performance

30 Devised an experiment to help understand something

31 Made up a joke

32 Been made a leader/captain of a team/group (e.g. Debating society chairperson, Captain of the Hockey team, etc.,)

33 Composed a piece of music

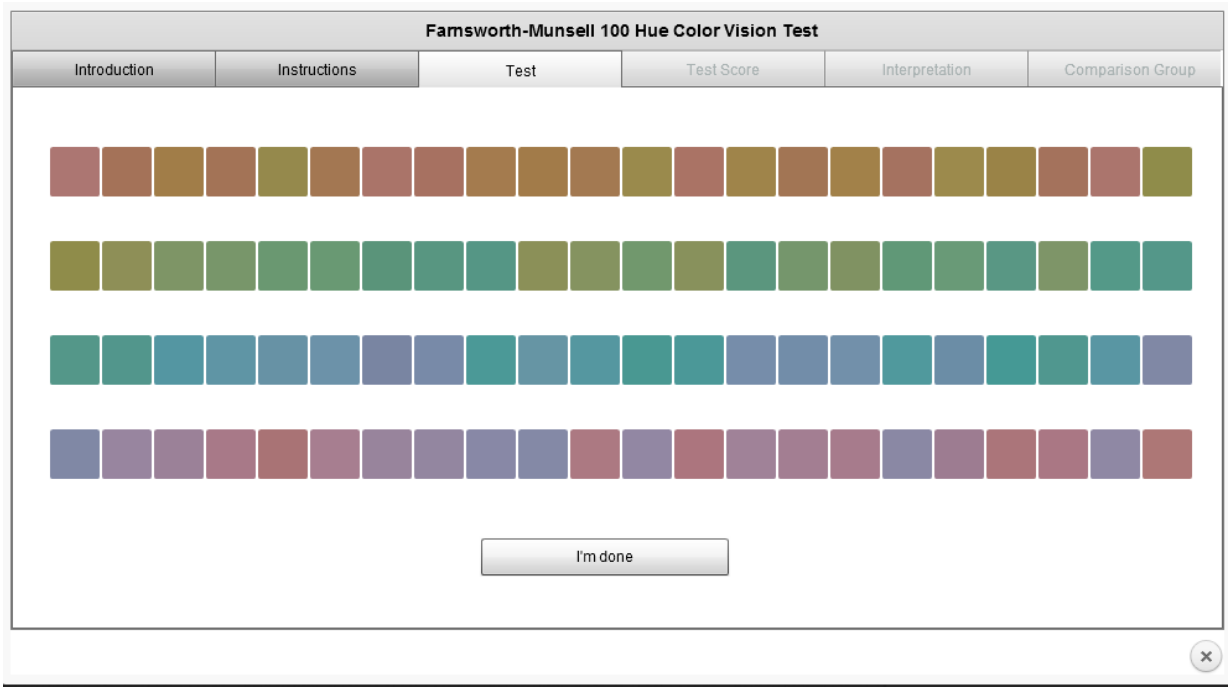
34 Made a collage

Appendix 2: Colour Perception Score

Farnsworth Munsell 100 hue test score:

Total error score = _____

Appendix 3: The Farnsworth-Munsell 100 Hue Colour Vision Test – Example Stimuli



Appendix 4: Creative Achievement Questionnaire

I. Place a check mark beside the areas in which you feel you have more talent, ability, or training than the average person.

__ Visual arts (painting, sculpture)

__ Music

__ Dance

__ Individual sports (tennis, golf)

__ Team sports

__ Architectural design

__ Entrepreneurial ventures

__ Creative writing

__ Humour

__ Inventions

__ Scientific inquiry

__ Theatre and film

__ Culinary arts

II. Place a check mark beside sentences that apply to you. Next to sentences with an asterisk (*), write the number of times this sentence applies to you.

A. Visual Arts (painting, sculpture)

__ 0. I have no training or recognized talent in this area. (Skip to Music).

__1. I have taken lessons in this area.

__2. People have commented on my talent in this area.

__3. I have won a prize or prizes at a juried art show.

__4. I have had a showing of my work in a gallery.

__5. I have sold a piece of my work.

__6. My work has been critiqued in local publications.

*__7. My work has been critiqued in national publications.

B. Music

__ 0. I have no training or recognized talent in this area (Skip to Dance).

__1. I play one or more musical instruments proficiently.

__2. I have played with a recognized orchestra or band.

__3. I have composed an original piece of music.

__4. My musical talent has been critiqued in a local publication.

__5. My composition has been recorded.

__6. Recordings of my composition have been sold publicly.

*__7. My compositions have been critiqued in a national publication.

C. Dance

__ 0. I have no training or recognized talent in this area (Skip to Architecture)

__1. I have danced with a recognized dance company.

__2. I have choreographed an original dance number.

__3. My choreography has been performed publicly.

__4. My dance abilities have been critiqued in a local publication.

__5. I have choreographed dance professionally.

__6. My choreography has been recognized by a local publication.

*__7. My choreography has been recognized by a national publication.

D. Architectural Design

__0. I do not have training or recognized talent in this area (Skip to Writing).

__1. I have designed an original structure.

__2. A structure designed by me has been constructed.

__3. I have sold an original architectural design.

__4. A structure that I have designed and sold has been built professionally.

__5. My architectural design has won an award or awards.

__ 6. My architectural design has been recognized in a local publication.

*__7. My architectural design has been recognized in a national publication.

E. Creative Writing

__0. I do not have training or recognized talent in this area (Skip to Humour).

__1. I have written an original short work (poem or short story).

__2. My work has won an award or prize.

__3. I have written an original long work (epic, novel, or play).

__4. I have sold my work to a publisher.

__5. My work has been printed and sold publicly.

__6. My work has been reviewed in local publications.

*__7. My work has been reviewed in national publications.

F. Humour

__0. I do not have recognized talent in this area (Skip to Inventions).

__1. People have often commented on my original sense of humour.

__2. I have created jokes that are now regularly repeated by others.

__3. I have written jokes for other people.

__ 4. I have written a joke or cartoon that has been published.

__5. I have worked as a professional comedian.

__6. I have worked as a professional comedy writer.

__7. My humour has been recognized in a national publication.

G. Inventions

__0. I do not have recognized talent in this area.

__1. I regularly find novel uses for household objects.

__2. I have sketched out an invention and worked on its design flaws.

__3. I have created original software for a computer.

__4. I have built a prototype of one of my designed inventions.

__5. I have sold one of my inventions to people I know.

*__6. I have received a patent for one of my inventions.

*__7. I have sold one of my inventions to a manufacturing firm.

H. Scientific Discovery

__0. I do not have training or recognized ability in this field (Skip to Theatre).

__1. I often think about ways that scientific problems could be solved.

__2. I have won a prize at a science fair or other local competition.

__3. I have received a scholarship based on my work in science or medicine.

__4. I have been author or co-author of a study published in a scientific journal.

*__5. I have won a national prize in the field of science or medicine.

*__6. I have received a grant to pursue my work in science or medicine.

__7. My work has been cited by other scientists in national publications.

I. Theatre and Film

__0. I do not have training or recognized ability in this field.

__1. I have performed in theatre or film.

__2. My acting abilities have been recognized in a local publication.

__3. I have directed or produced a theatre or film production.

__4. I have won an award or prize for acting in theatre or film.

__5. I have been paid to act in theatre or film.

__6. I have been paid to direct a theatre or film production.

*__7. My theatrical work has been recognized in a national publication.

J. Culinary Arts

__0. I do not have training or experience in this field.

__1. I often experiment with recipes.

__2. My recipes have been published in a local cookbook.

__3. My recipes have been used in restaurants or other public venues.

__4. I have been asked to prepare food for celebrities or dignitaries.

__5. My recipes have won a prize or award.

__6. I have received a degree in culinary arts.

*__7. My recipes have been published nationally.

K. Please list other creative achievements not mentioned above.

Appendix 5: Interpersonal Reactivity Index

The following statements inquire about your thoughts and feelings in a variety of situations. For each item, indicate how well it describes you by choosing the appropriate letter on the scale at the top of the page: A, B, C, D, or E. When you have decided on your answer, fill in the letter on the answer sheet next to the item number. READ EACH ITEM CAREFULLY BEFORE RESPONDING. Answer as honestly as you can. Thank you.

ANSWER SCALE:

A	B	C	D	E
DOES NOT DESCRIBE ME WELL				DESCRIBES ME VERY WELL

1. I daydream and fantasize, with some regularity, about things that might happen to me.

2. I often have tender, concerned feelings for people less fortunate than me.

3. I sometimes find it difficult to see things from the "other guy's" point of view.

4. Sometimes I don't feel very sorry for other people when they are having problems.

5. I really get involved with the feelings of the characters in a novel.

6. In emergency situations, I feel apprehensive and ill-at-ease.

7. I am usually objective when I watch a movie or play, and I don't often get completely caught up in it.

8. I try to look at everybody's side of a disagreement before I make a decision.

9. When I see someone being taken advantage of, I feel kind of protective towards them.

10. I sometimes feel helpless when I am in the middle of a very emotional situation.

11. I sometimes try to understand my friends better by imagining how things look from their perspective.

12. Becoming extremely involved in a good book or movie is somewhat rare for me.

13. When I see someone get hurt, I tend to remain calm.

14. Other people's misfortunes do not usually disturb me a great deal.

15. If I'm sure I'm right about something, I don't waste much time listening to other people's arguments.

16. After seeing a play or movie, I have felt as though I were one of the characters.

17. Being in a tense emotional situation scares me.

18. When I see someone being treated unfairly, I sometimes don't feel very much pity for them.

19. I am usually pretty effective in dealing with emergencies.

20. I am often quite touched by things that I see happen.

21. I believe that there are two sides to every question and try to look at them both.

22. I would describe myself as a pretty soft-hearted person.

23. When I watch a good movie, I can very easily put myself in the place of a leading character.

24. I tend to lose control during emergencies.

25. When I'm upset at someone, I usually try to "put myself in his shoes" for a while.

26. When I am reading an interesting story or novel, I imagine how I would feel if the events in the story were happening to me.

27. When I see someone who badly needs help in an emergency, I go to pieces.

28. Before criticizing somebody, I try to imagine how I would feel if I were in their place.

Appendix 6: The Alternate Uses Test, Form B Test Booklet – Example Stimuli

Name as many possible uses as you can think of for each common household item:

1. Brick
2. Paperclip
3. Newspaper

Appendix 7: The Eyes Test (Theory of Mind) – Example Stimuli

jealous panicked

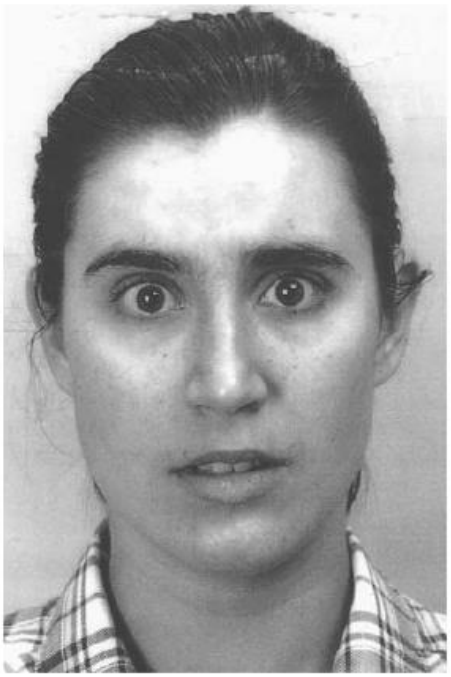
arrogant hateful

playful comforting

irritated bored

Appendix 8: The Faces Test (Theory of Mind) – Example Stimuli

SURPRISE



ANGRY

HAPPY

AFRAID

Appendix 9: Toronto Empathy Questionnaire

Below is a list of statements. Please read each statement *carefully* and rate how frequently you feel or act in the manner described. There are no right or wrong answers or trick questions. Please answer each question as honestly as you can.

Never = 0; Rarely = 1; Sometimes = 2; Often = 3; Always = 4.

Write the most appropriate number as your answer next to the question.

1. When someone else is feeling excited, I tend to get excited too
2. Other people's misfortunes do not disturb me a great deal
3. It upsets me to see someone being treated disrespectfully
4. I remain unaffected when someone close to me is happy
5. I enjoy making other people feel better
6. I have tender, concerned feelings for people less fortunate than me
7. When a friend starts to talk about his\her problems, I try to steer the conversation towards something else
8. I can tell when others are sad even when they do not say anything
9. I find that I am "in tune" with other people's moods
10. I do not feel sympathy for people who cause their own serious illnesses
11. I become irritated when someone cries
12. I am not really interested in how other people feel
13. I get a strong urge to help when I see someone who is upset
14. When I see someone being treated unfairly, I do not feel very much pity for them
15. I find it silly for people to cry out of happiness
16. When I see someone being taken advantage of, I feel kind of protective towards him\her

Appendix 10: Highly Sensitive Person Scale

INSTRUCTIONS: This questionnaire is completely anonymous and confidential. Answer each question according to the way you personally feel, using the following scale:

1	2	3	4	5	6	7
Not at All			Moderately			Extremely

____ 1. Are you easily overwhelmed by strong sensory input?

____ 2. Do you seem to be aware of subtleties in your environment?

____ 3. Do other people's moods affect you?

____ 4. Do you tend to be more sensitive to pain?

____ 5. Do you find yourself needing to withdraw during busy days, into bed or into a darkened room or any place where you can have some privacy and relief from stimulation?

____ 6. Are you particularly sensitive to the effects of caffeine?

____ 7. Are you easily overwhelmed by things like bright lights, strong smells, coarse fabrics, or sirens close by?

____ 8. Do you have a rich, complex inner life?

____ 9. Are you made uncomfortable by loud noises?

___ 10. Are you deeply moved by the arts or music?

___ 11. Does your nervous system sometimes feel so frazzled that you just have to go off by yourself?

___ 12. Are you conscientious?

___ 13. Do you startle easily?

___ 14. Do you get rattled when you have a lot to do in a short amount of time?

___ 15. When people are uncomfortable in a physical environment do you tend to know what needs to be done to make it more comfortable (like changing the lighting or the seating)?

___ 16. Are you annoyed when people try to get you to do too many things at once?

___ 17. Do you try hard to avoid making mistakes or forgetting things?

___ 18. Do you make a point to avoid violent movies and TV shows?

___ 19. Do you become unpleasantly aroused when a lot is going on around you?

___ 20. Does being very hungry create a strong reaction in you, disrupting your concentration or mood?

___ 21. Do changes in your life shake you up?

___ 22. Do you notice and enjoy delicate or fine scents, tastes, sounds, works of art?

___ 23. Do you find it unpleasant to have a lot going on at once?

___ 24. Do you make it a high priority to arrange your life to avoid upsetting or overwhelming situations?

___ 25. Are you bothered by intense stimuli, like loud noises or chaotic scenes?

___ 26. When you must compete or be observed while performing a task, do you become so nervous or shaky that you do much worse than you would otherwise?

___ 27. When you were a child, did parents or teachers seem to see you as sensitive or shy?

Appendix 11: Two-Factor Imagination Scale

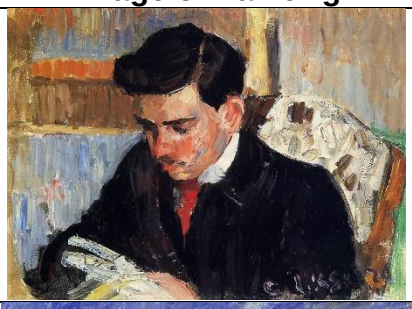
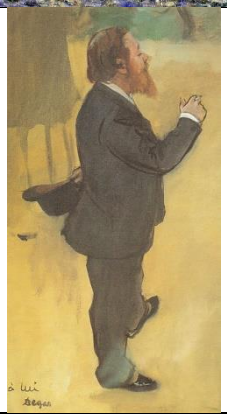
Instructions: Answer the following questions. If a question simply does not apply, leave it out completely and continue with the next. Each question can have one of 2 possible answers. Please tick the most appropriate.

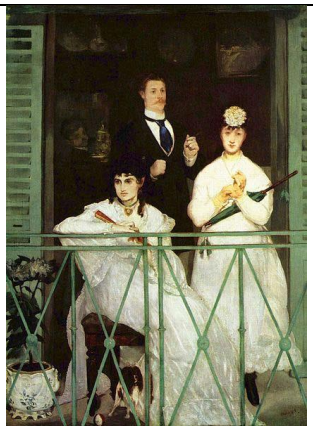
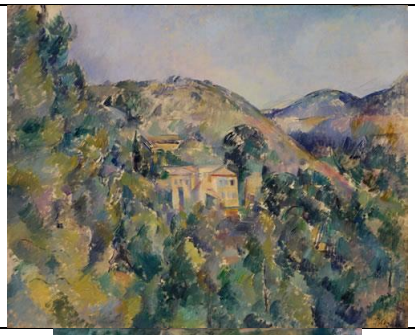
	More Often True	**Less Often True**
My imagination persistently generates daydreams and fantasies without any conscious effort on my part		
My daydreams and fantasies frequently produce unexpected themes		
Elaborate imaginary themes often come to me instantaneously, seemingly out of nowhere		
The products of my imagination are usually ones that I initiate; i.e. they generally don't come on their own		
My imagination is usually not spontaneous and surprising, but rather is used/employed in a more controlled fashion		
I tend to terminate imaginal exercises once I have reached a pre-determined or desired goal of the activity		
When designing or inventing something, or when participating in artistic activities, my imagination often directs the process with little mental deliberation		

I am frequently astonished at the scenarios my imagination generates		
My imagination produces elaborate scenarios in an instant without prior deliberation on the theme		
Imagining is an act I choose to commence; it is rarely something that just “happens to me”		
I tend to guide the direction of my imaginative processes, rather than relying on the possibility that imagination will autonomously guide the process		
I usually terminate impractical or unwanted imaginal exercises by distracting myself, emptying my mind, or by initiating a brand new exercise in imagination		
When a friend feels upset my imagination automatically generates an internal image of their predicament, helping me to understand what they are feeling		
My imagination tends to conjure/suggest realities contrary to those I would habitually expect		
The images and scenarios of my imagination usually take time and persistence to construct		
I use my imagination mainly for practical means, e.g., like how to work out a problem or construct a useful idea or object		

When I imagine something I prefer to control the contents, direction, spatial character, and duration of the imagined scenario		
I tend to allow imaginative experiences to reach their own natural conclusion, rather than me calling a halt to the activity		
The products of my imagination take considerable effort to construct		
The products of my imagination are generally predictable		
I frequently find myself imagining something, even when I have not chosen to do so!		
I often do not have control, nor take control of an imaginative experience, but allow the contents, direction and spatial characteristics of the imaginal presentation to direct themselves		

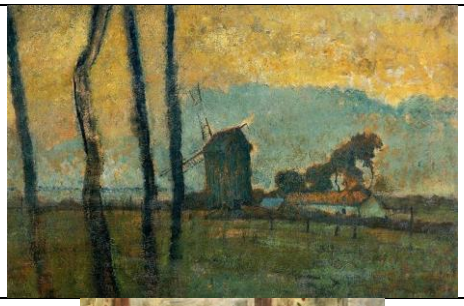
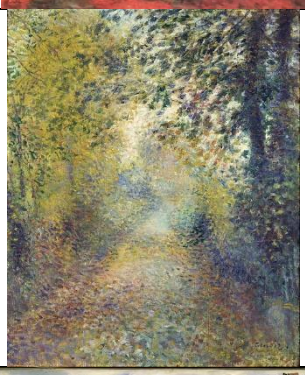
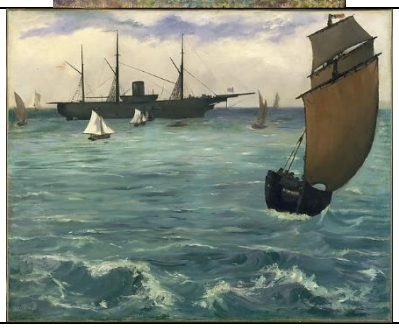
Appendix 12: Images of Paintings (shown in order as seen by participants)

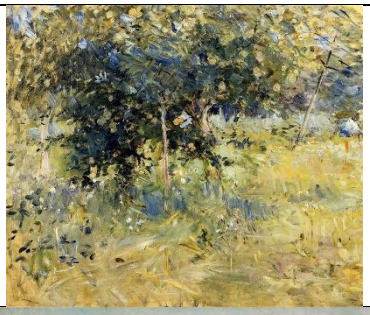
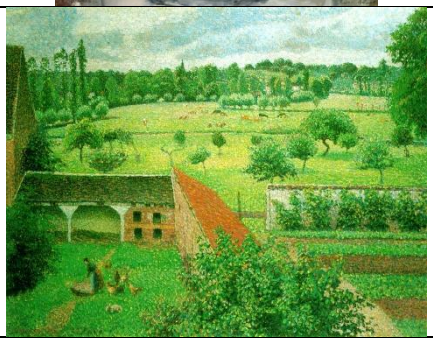
Image of Painting	Name of Artist	Name of Painting
	Camille Pissarro	Portrait of Rodo Pissarro Reading (the Artist's Son) 2
	Pierre-Auguste Renoir	The Doge's Palace
	Hilaire-Germain-Edgar Degas	Carlo Pellegrini

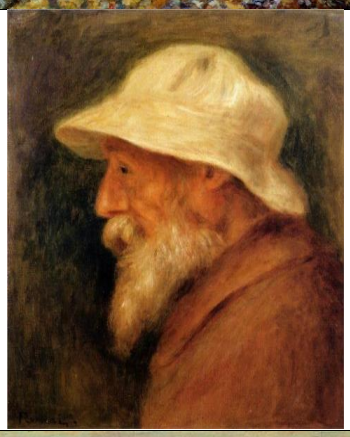
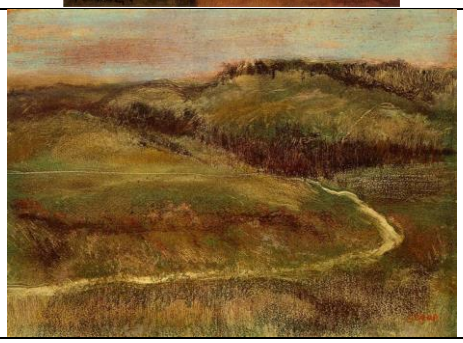
	Edouard Manet	The Balcony
	Paul Cézanne	View of The Domaine Saint-Joseph
	Hilaire-Germain-Edgar Degas	Two Dancers On Stage

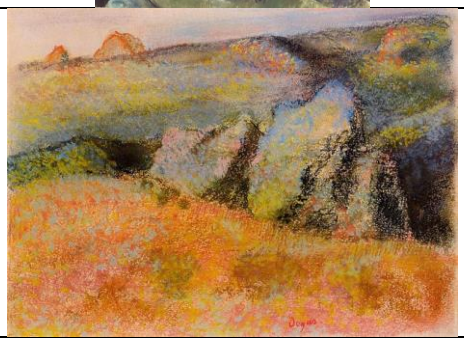
	Hilaire-Germain-Edgar Degas	Portrait of Elena Carafa
	Pierre-Auguste Renoir	Landscape at Beaulieu
	Pierre-Auguste Renoir	Jeanne Samary in a Low Necked Dress

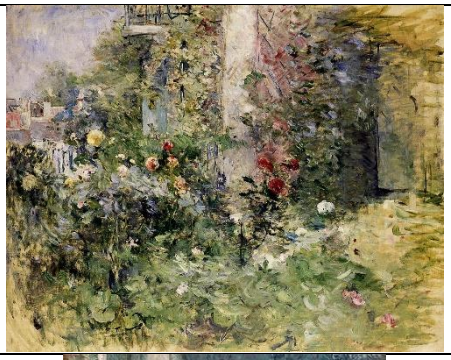
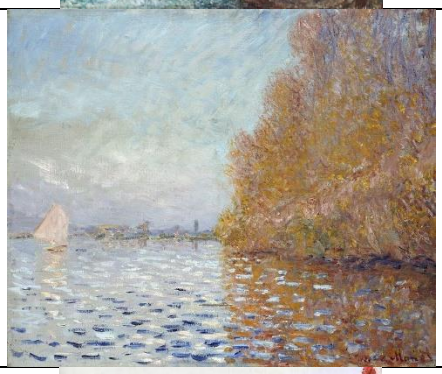
	Paul Cézanne	Forest
	Claude Monet	Self Portrait
	Camille Pissarro	Portrait of Jeanne
	Claude Monet	Portrait of Blanche Hoschede

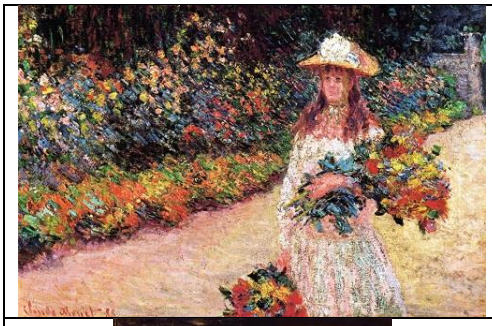
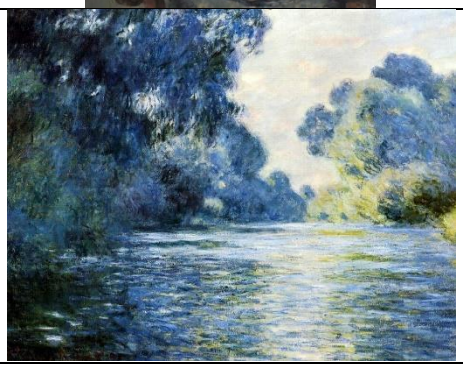
	Hilaire-Germain-Edgar Degas	Landscape at Valery-sur-Somme
	Berthe Morisot	Psyche
	Pierre-Auguste Renoir	In the Woods
	Edouard Manet	The Kearsarge at Boulogne

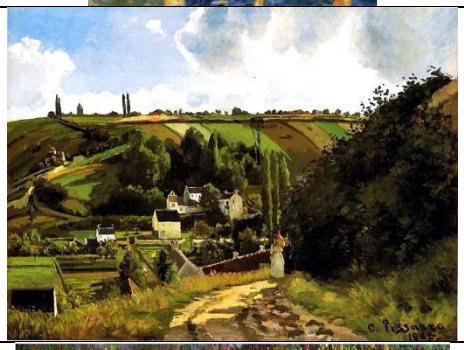
	Berthe Morisot	Willows in the Garden at Bougival
	Paul Cézanne	Mont Sainte-Victoire seen from Bellevue
	Berthe Morisot	At The Ball
	Camille Pissarro	View from my Window, Eragny

	Claude Monet	San Giorgio Maggiore at Dusk
	Camille Pissarro	Hoar Frost
	Pierre-Auguste Renoir	Self-Portrait with a White Hat
	Hilaire-Germain-Edgar Degas	Landscape

	Paul Cézanne	Pierrot and Harlequin
	Edouard Manet	The Battle of the Kearsarge and the Alabama
	Paul Cézanne	The Boy in the Red Vest
	Hilaire-Germain-Edgar Degas	Landscape with Rocks

	Berthe Morisot	The Garden at Bougival
	Camille Pissarro	Peasant Girl Drinking her Coffee
	Edouard Manet	Argenteuil Basin with a Single Sailboat
	Berthe Morisot	On the Balcony

	Claude Monet	Young Girl in the Garden at Giverny
	Edouard Manet	Portrait of Emile Zola
	Paul Cézanne	Woman in a Green Hat. Madame Cézanne
	Claude Monet	Branch of the Seine near Giverny

	Edouard Manet	The Fifer
	Berthe Morisot	Hollyhocks
	Pierre-Auguste Renoir	By the Seashore
	Camille Pissarro	Jallais Coast, Pontoise
	Claude Monet	Artist's Garden at Giverny